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THE INSTITUTE OF PETROLEUM

AN Ordinary General Meeting of the Institute of Petroleum was held at 26 Portland Place, London, W.1, on 6 March 1957, the Chair being taken by A. C. Hartley, C.B.E., a vice-president of the Institute.

The General Secretary read the minutes of the previous meeting, which were confirmed and signed as a correct record. He also announced the names of members elected since the previous meeting.

The Chairman, introducing Dr A. T. Dennison, regretted that H. R. Warman, the co-author of the paper, was unable to be present, but welcomed I. Gillespie in his place.

The following paper was then presented in summary.

RECENT TRENDS IN EXPLORATION METHODS*

By A. T. DENNISON † and H. R. WARMAN †

SUMMARY

The main feature of oil exploration at present is the absence, and apparent unlikelihood, of the development in the near future of any revolutionary techniques. The search for new and more obscure reserves of oil is pursued largely by refinements of earlier methods. The seismic reflection method maintains its predominant position among the geophysical techniques, and there is a marked tendency in reflection work to replace the conventional oscillograph recorder by systems making playback facilities available.

INTRODUCTION

THE tempo of oil exploration and the methods used in pursuing the search for oil and gas are dictated by three fundamental factors:

(1) The economic climate in which the oil industry operates and the political and economic pressures affecting the location of its operations.

(2) The blend of creative imagination and practical experience applied in directing the policies of oil exploration.

(3) The availability of technical and scientific invention and knowledge on which the oil industry can draw for its own application.

Since 1945 the economies of most countries in the world have been expanding rapidly, and within these economies the oil industry has probably prospered as much as any. Under these conditions, there has essentially been a demand for ever-increasing oil production, and with it an increase in the search for new reserves. The prosperity of the oil industry has provided the large capital required for expanding exploratory effort. Political factors have influenced the areas of operation of oil companies to a considerable extent during this period. The political instability of the Middle East has encouraged oil exploration in countries such as Africa, where the oil prospects are highly speculative and operating conditions difficult.

Allied to the above pressures and the present profitability of oil accumulations of nearly all sizes, two other factors direct the search for oil to outwardly less attractive areas. First, there is the obvious tendency for the larger and more conspicuous oil accumulations to be found first and for oilfields to become increasingly more difficult to detect. Secondly, the experience of the oil industry is that very few of the basins of sedimentary rocks in the world are completely lacking in oil accumulation and that diligent exploratory methods will find them. The success of the German oil industry since 1945 is an object lesson in the value of an optimistic, sustained application of all possible techniques.

The oil industry now finds itself embarked on a programme of increasingly expensive exploration and, particularly in its geophysical prospecting, of spending large sums of money on fundamental and applied research and on re-equipping with more complex and highly developed equipment.

GENERAL TRENDS OF EXPLORATION METHODS

As there are no new methods of locating oil in place without drilling exploration holes, the fundamental principles of searching for oil remain unchanged and the problem remains one of locating suitable structures in beds of suitable characters to act as reservoirs. As the search for deeper horizons and in more obscure and inaccessible regions progresses, increasing use is made of geophysical methods of search for structures. With the search extending to geologically less well-known horizons, it becomes increasingly important to

* MS received 1 February 1957.

† The British Petroleum Co. Ltd.

integrate geophysical results with geological knowledge, obtained if necessary by boreholes drilled purely for stratigraphic information and for measurements of velocity distribution, etc. Most of the changes in technique have been in geophysical methods and instrumentation, and some of these are outlined below.

It may seem a reflection on the methods of the oil industry of the past, but it is probably true to say that only recently has the need to integrate fully the methods and approaches of geophysics and geology obtained a satisfactory response. The need is, of course, mutual and stems from operating in areas where the unknowns and difficulties are sufficient to necessitate the augmenting of physical measurement with the intuitive approach of most geologists who are more accustomed to producing an answer to structural problems from incomplete and indirect evidence.

TRENDS IN GEOLOGICAL METHODS

The pressure of demand for new oil reserves has forced exploration into regions without oil indications and where the very existence of suitable sediments for oil generation and accumulation is unknown. It has also forced companies to operate in areas of great physical difficulty. Not only have geologists been forced to resort to new methods of transport such as "marsh-buggies," helicopters, and snow-tractors, not to mention the use of aqualungs to explore the sea bed, but an increasing use is being made of photogeology. In territory with difficult terrain, aerial photographs can be used to connect traverse lines made by geologists on the ground and thus produce a map showing at any rate the main features of the geology. Air photographs can be used to produce topographic maps both for planning ground reconnaissance and also as the base for geological maps. The amount of detailed geology that can be obtained from air photographs varies with the climate and vegetation of an area, and also depends on the topography. In the arid mountains of the Middle East, a map produced from a complete cover of overlapping vertical photographs and checked by a few ground traverses can produce a geological map adequate for almost all purposes. Even in countries covered by tropical rain forest, much extremely difficult ground reconnaissance can be avoided by a few lines of vertical photographs coupled with oblique shots taken on both sides of the flight paths.

A considerable increase has taken place recently in the search for oil offshore. Geologically the sea bed is no different from the land except that it is obscured by water and usually also by recent sediments, *i.e.* sands, mud, coral reefs, etc. Where there is new sediment, geophysical methods are the only possible way of exploring the rock structures, but in some areas marine currents keep the sea floor clean and attempts have been made to map and sample the underwater rocks by geologists using aqualung diving equipment and by various types of sampling apparatus. As far as is generally known, such methods have achieved little practical result, and the future prospects for this work are limited.

In addition to the increasing exploration in new areas, much attention has recently been paid to locating, within proved oil provinces, the undiscovered and smaller accumulations that have escaped previous exploration. These more obscure oil accumulations are largely stratigraphic traps that depend on the trapping of oil or gas by changes of porosity and permeability within a reservoir series, by lensing out of reservoir beds, and by unconformities. The search for these accumulations is not new, but a great deal more attention has been paid recently to the careful analysis of all the information from surface exposures, boreholes, and geophysical work in order to elucidate the geological history for the purpose of prediction of thickness variation, facies change, minor unconformities, etc. Detailed studies of the geology of areas call for the preparation of maps showing the structure of the rocks at different depths and the variations in thickness and lithology of various potential reservoir beds. There is thus an increasing demand for detailed cartography and draughtsmanship, and the graphical-pictorial expression of variable factors.

Considerable attention is being paid to the long familiar problems of the source material of crude oil and the parallel problem of correlating types of oil with beds of particular type and age. It is hoped that research on these lines may produce evidence useful for allocating exploratory effort to more restricted parts of sedimentary basins, but at present such research has yielded little of practical value.

Exploration geology, in common with all geology concerned with the nature of rocks and the fluids they contain, makes increasing use of modern techniques that belong more properly to the realms of physics or chemistry. Both in survey work and more particularly in studies of reservoir rocks, considerable use is made of methods of mineral determination such as arc spectrography, X-ray diffraction, and differential thermal analysis. The distribution of trace elements is sometimes used for the correlation of a succession of rocks in boreholes that cannot be differentiated by visual or electric logging techniques. The nature of the clay minerals in reservoir sandstones determines the best petroleum engineering procedures, and the above techniques play an essential part in identifying minerals.

Increasing use is made of the properties of fluorescence of hydrocarbons. In the examination of cuttings and cores from boreholes, potential reservoir beds are examined for fluorescence, and frequently paper-chromatography is used to differentiate any

hydrocarbons present. Despite the recent proving in the U.S.A., by dating with radioactive carbon, that soils contain geologically recent crude oil, considerable attention is still paid, particularly by research workers, to surveying the hydrocarbon content of soils and near-surface rocks for hydrocarbon traces connected with deeper buried accumulations. Fluorescence and chromatography are particularly suited to this work. Surface mapping of hydrocarbons, however these are detected or analysed, does not yet seem to be making a very valuable contribution to the discovery of new oilfields, and its prospects appear limited.

Geochemical research for geological purposes is being actively pursued by most of the major American oil companies, some of which maintain large and expensive facilities for this work.

TRENDS IN GEOPHYSICAL METHODS

In discussing recent trends in the geophysical methods of prospecting for oil, it seems convenient to take as a starting point a paper read to the IP in 1953.[1] This dealt with the problems and trends in geophysical methods as they appeared at that time; an attempt will be made here to define the subsequent trends as far as they can be distinguished in what is a relatively short time interval.

It can be said, first, that the general problems facing the geophysicist today are essentially similar to those existing in 1953, although some progress has been made towards solving a number of them. These general problems can be summarized as follows:

(1) To increase the accuracy and resolving power of geophysical methods.

(2) To increase the speed of operation in areas of difficult terrain.

(3) To extend the use of the reflection method into "no-reflection" areas, since this method is the most accurate of those available at the present day.

(4) To develop new methods which will give a direct indication of oil accumulation rather than of geological structures.

Of these four aspects of development, (1), (2), and (3) have all shown some progress; the smallest advance is certainly in (4), where the position has not changed appreciably since 1953, a most disappointing position from all points of view.

As a broad generalization, it is perhaps fair to say that in the past few years it has been more widely appreciated that in any attempt to obtain the maximum resolution from geophysical methods, very close attention must be paid to the detailed corrections required in handling the data. Whilst the need for corrections is fairly obvious, experience has shown that in many areas the need is greater than was anticipated, and it is, of course, increased by the search for ever-smaller structures. The best example of this is the problem of near-surface velocities in reflection surveys. It is now not uncommon to deepen the shot holes at regular intervals so that up-hole shooting can give better control of variations in these velocities and the so-called "high-resolution" technique has been used for the same purpose.

The areas of difficult terrain, from tropical rain forest to the Rocky Mountain foothills of Canada, present the instrument designer with stringent specifications on reliability and portability. Although perfection on these points can never be achieved, an acceptable standard of instrument design had already been reached in 1953. The only appreciable improvement in this respect which can be foreseen at the moment is that the use of transistors should improve both reliability and portability in the next few years, provided that certain technical problems can be overcome.

Improvements have, however, been made in the larger pieces of equipment which are required for a geophysical survey. Small and highly portable shot-hole drills have been designed for both man-pack and vehicle-mounted operation. Equally important have been the improvements in vehicle design to cope with the various types of surface. Thus, geophysical requirements in Canada have led to the development of a variety of tracked vehicles and also to the use of more standard vehicles having a hinged chassis to reduce the stresses imposed by rough surfaces. The increasing use of the helicopter has been a significant factor in speeding up geophysical work in many parts of the world, although in heavily-timbered regions their use is not as simple as might appear at first sight. In the very difficult areas the helicopter has appreciably reduced the physical strain on the geophysical crews, and, apart from the improvement in speed of working, this should help to improve the quality of the data obtained.

A considerable amount of research effort has been put into ways of obtaining workable reflections in the so-called "no-reflection" areas. This has resulted in improved methods of shooting, revised geophone patterns, and, most recently, in the replacement of explosive as the energy source by a falling-weight (the McCollum Geograph). It is, however, realized that none of these methods is a golden wand which can produce the required answer in all areas. Each new area must be tackled as a separate problem, and fresh developments of technique merely increase the number of tools at the disposal of the geophysicist and from which he must choose in planning his work. Thus the use of multiple geophones has for some time now been a standard tool to be used when required; in this particular case there is a tendency to use it as

a routine technique, even perhaps where it is not strictly necessary.

Before dealing with the geophysical methods in detail, mention must be made of perhaps the most striking trend of recent years, a trend which has become particularly marked in the past two years. This is the increasing use of " wide-band " methods of recording seismic signals, with facilities for later playback and manipulation of the records. Most oil companies are changing over to this type of recording, with the greatest emphasis being on magnetic recording systems, since it contributes towards the three points (1), (2), and (3) above. This development was in its experimental stage in 1953, but in view of its recent rapid growth and with the increasing availability of suitable equipment, it now seems likely that 80 per cent of seismic crews will be equipped with such apparatus within a further two years. This changeover, with the consequent introduction of semi-automatic data handling machinery into the interpretation office, is discussed in more detail below.

Magnetic Surveys

Magnetic methods of prospecting receive a relatively limited amount of publicity in the journals of the oil industry at the present time, but the published figures of worldwide geophysical activity [2] show only a slight decline in the use of the method. The data are, however, incomplete, and since the figures do not distinguish between ground and airborne methods, they could be most misleading. They do, however, indicate a sharp decline in magnetic prospecting in the U.S.A. and Canada and an increase in the Eastern Hemisphere.

Such changes would accord with the present view that this method, measuring as it does primarily the effects of the basement rocks, is mainly useful in defining the shape of sedimentary basins. Subject to certain assumptions in the calculations, the results may also be used to indicate the depth of the sedimentary succession in these basins, and very useful results have been obtained in this way. The scope for this type of preliminary reconnaissance survey will clearly diminish in the future, but it may well be some years before a decline in the Eastern Hemisphere becomes apparent.

Gravity Surveys

The number of gravity surveys carried out in petroleum prospecting appears to have risen gradually since about 1950, both in absolute terms and also in relation to the number of seismic surveys. On the figures available, this increase has been greatest in the Eastern Hemisphere and there are significant differences between North America and elsewhere in the proportions of seismic and gravity work. In North America the ratio of seismic to gravity work in terms of crew-months/year is about 10 : 1; in the Eastern Hemisphere about 3 : 1. The main reason for this difference is probably the intensive and detailed nature of many of the surveys in North America, which must therefore use the seismic method.

Whilst gravity surveys have been extensively used in the past for preliminary reconnaissance work, particularly in view of their relative cheapness, it has become apparent that without a considerable amount of geological information on the area concerned, gravity surveys can give information which is either misleading or of very doubtful value. Without information on basement depth or the density distribution of the sedimentary column, the choice of gravity anomalies as drilling sites must depend largely on their shape, since it is not known whether positive or negative ones are of interest, and there is always the possibility that the anomalies represent basement variations which are independent of the sedimentary succession.

For these reasons, it is usually considered that supporting seismic evidence is required before a gravity anomaly becomes a drilling site. Exceptions to this occur, however, when the probable geology and the type of target structure are known, and in such special cases a gravity survey can be a quick and accurate exploration tool. The salt-dome structures of the Gulf Coast provide one example of this. Another is provided by a recent paper [3] describing the successful location of reef structures by their small gravity anomalies. This paper does, however, illustrate the difficulties of the method; depending on the interplay of several variable factors, these particular reefs could result in either a positive or negative or in no anomaly in the surface gravity map. Consequently, some reefs may not be located and, conversely, it has been found by drilling that not all the anomalies in the area were in fact due to reef structures.

Seismic Refraction Surveys

Whilst the refraction method has been used continuously for many years by geophysical parties controlled from Europe, it was used very little in North America in the period 1946–52, being regarded in part as an " old-fashioned " method. There was a revival of interest in the method in North America in the early 1950s, and although no figures are available on the number of refraction parties employed, it has been used in West Texas, in Florida, and in the Canadian foothills region. " Second arrival " techniques have been employed in much of this work, and their use has been facilitated in Canada by the existence of a refractor giving a very high energy return, a condition which is particularly desirable if the uncertainties of second arrival measurements are to be minimized.

Whilst it is agreed that the seismic reflection method

is more accurate, the refraction method gives a much higher output in terms of miles/month, and is therefore particularly useful for locating areas which appear to justify more detailed work by the reflection technique. It can also be used, as it has been in West Texas and in Europe, for detailed work in areas where workable reflections are difficult to obtain. In such areas much time can be wasted in finding the optimum reflection technique, and it may be a better economic proposition to carry out a detailed refraction programme.

Use of the refraction method does, however, require the existence of a horizon which has a considerably higher velocity than those above it and which is conformable with the geological horizons of interest. This particular restriction does not apply to the reflection method, although even here reflections must, of course, be obtainable either from the horizon of interest or from a conformable horizon.

Seismic Reflection Surveys

Over 80 per cent of the geophysical exploration effort, in terms of crew-months, is devoted to the reflection method of prospecting; in terms of cost, the proportion is considerably higher, since it is a relatively expensive method. The concentration on this method, both in the field and in development research, can, however, be justified by its accuracy and the amount of information it can yield. This is, of course, subject to usable field records being obtained, and in a number of areas this qualification is of considerable importance.

Where reflection quality is good, it is usually possible to plot accurately the contours of a number of geological interfaces, at depths ranging from a few hundred to over 20,000 ft. It is tempting to assume that the separate "reflections" seen on a record correspond to individual geological horizons, but recent work, such as that by Woods,[4] has shown that in many cases they may be composite signals formed by reflections from a number of closely-spaced interfaces. Small changes in the spacing or nature of these interfaces could change the form of this composite signal appreciably, so that the reflections may appear either to be discontinuous along a profile or to change their character. Even where these changes do not occur, considerable caution must be used in establishing the correlation between the reflection and its equivalent point in the geological succession, due regard being paid to the effects of the recording instruments on the apparent reflection time. To assist in this correlation, "synthetic" seismograms have been widely used in recent months. These are seismic records prepared in the laboratory from a knowledge of the detailed velocity distribution in the ground, this information being obtained from a continuous velocity log run in a nearby borehole. Ideally, this synthetic seismogram should correspond very closely to the field records obtained in practice, and it then becomes possible to isolate the effects of the various horizons on the field record. Owing to the assumptions which have to be made, the laboratory seismogram usually gives only moderate agreement with the field seismogram, but the method has given very useful results.

A considerable amount of publicity has been given recently to the so-called "high-resolution" technique. This consists, essentially, of extending the upper frequency limit of the recording equipment from its previous value of 100 c.p.s. to about 500 c.p.s., although the useful limit appears to be about 250 c.p.s. The reflected energy in this higher frequency band is generally less than that at lower frequencies, but its use makes it possible to obtain more detailed information at depths down to 3000 ft in certain areas and also to record reflections from very shallow horizons, say 250 ft deep. The theory of the method has been indicated by Olson [5] and a preliminary evaluation given by Pakiser and Warrick.[6]

The McCollum weight-dropping technique, mentioned earlier, is being tested by a number of oil companies. The usual explosive charge is here replaced by a 3-ton weight which is allowed to fall about 9 ft on to the ground; the resultant seismic energy is reported to be equivalent to that from about 2½ lb of dynamite. It is therefore necessary to add together the records from, say, ten drops to obtain a satisfactory signal-to-background noise ratio. In practice, these ten drops are made at different points on the ground to give in addition an improved signal-to-shot-noise ratio. Using magnetic tape-recording equipment, a high rate of working has been achieved, but the general usefulness of the method remains to be proved. It is claimed to give good results in caliche areas, which are notoriously difficult for reflection recording, and clearly has possibilities in areas of difficult shot-hole drilling or where the risk of property damage precludes the use of dynamite.

These two latter developments, whilst significant in themselves, are overshadowed at the moment by the widespread changeover of many seismic parties to methods of recording which are suitable for "playback." This does not signify any change in the basic principles of the method, but it has produced considerable changes in equipment design and in field and interpretational procedures. The changes can best be summarized by a brief outline of such a system, bearing in mind that each oil company will prefer its own variant of this outline. Although two major companies appear to prefer variable-area and variable-density photographic recording methods respectively (Fig 1), the magnetic system will be described here, since it will be the one most widely used. The comparative technical advantages of the different methods will not be discussed, and the

following description of a magnetic recording system is given in general terms, since particular equipments vary considerably in their details. With all these equipments, however, one main objective is to record in permanent and accessible form all the seismic data obtained from each seismic shot. With earlier equipments, only a selected and limited part of the data could be recorded in general, and the new system should therefore result in improved use of the expensive field work.

The party in the field uses recording amplifiers and geophones essentially similar to those previously used, but the amplifier pass band preferably includes frequencies up to 250 c.p.s. The outputs of the

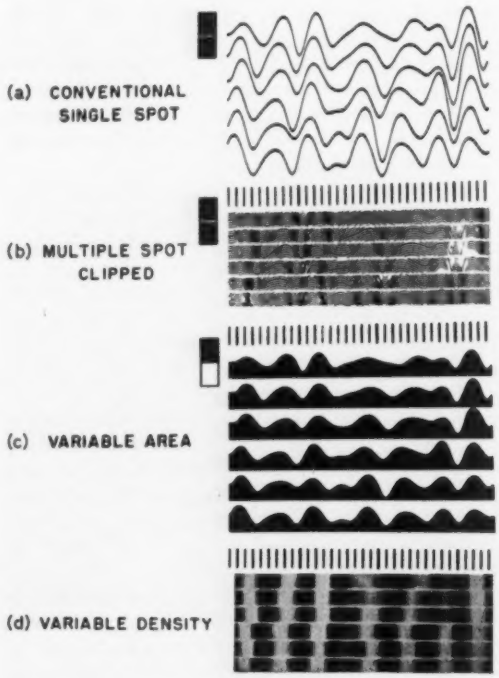


FIG 1

ALTERNATIVE FORMS OF SEISMIC RECORD PRESENTATION

amplifiers are fed, not to the conventional oscillograph, but to a unit where the signals are recorded on magnetic tape, each tape being about 4 inches wide and accommodating 28 recording channels. With this equipment, the aim is to record the seismic energy, not through a series of filters designed to give the optimum signal-to-noise ratio, but in a "wide-band" form, *i.e.* so that the recorded information exactly duplicates that given by the geophones. In practice, however, instrumental limitations make it necessary to use some form of automatic gain control and, occasionally, a minimum amount of high-pass filtering. Some form of monitor system is usually provided so that the observer can examine the record visually in the field.

It must be emphasized here that subsequent processing can only compensate for a faulty field technique to a very limited extent. It is still essential to use the correct size and depth of shot and the optimum layout of the geophone spread.

The wide-band record is usually returned to the field base for processing. This processing depends on the fact that a magnetic tape record can be played back to reproduce the original electrical signals; these can then be recorded on a conventional oscillograph to give a visual record, or recorded again on another magnetic tape, after filtering or mixing. The original tape is unchanged by the playback process, and may be stored permanently.

The first logical step in processing is the insertion of the trace time corrections arising from elevation and weathering differences between geophone stations and from normal step-out. The former are known as static corrections, being constant for all points on a given trace; the step-out correction varies with the reflection time and is termed the dynamic correction. The latest playback machines have facilities for inserting both these types of correction whilst the signals are being transferred from one tape to another, and this step is important, both for the profile assembly described below, and as a preliminary to trace mixing.

The second, corrected, tape can now be played back through various filter combinations to determine the most suitable one for the reflections of interest, the final record being in visual form for computation and interpretation. More than one final record may be desirable, for example, one corresponding to a high-frequency filter for shallow reflections, and a lower-frequency one for deeper reflections. Mixing and compositing of traces can be carried out between the filtering and the making of the final visual record.

Thus, the interpretation offices now have control of the instrumental settings to be used in preparing the final record, and these can be changed either from record to record or during a review of the work at a later date when additional information, *e.g.* well-velocity data, is available or when interest has shifted to a different geological horizon. This is, of course, subject to any limitation imposed by the particular field technique used.

In parallel with this development in recording technique, there has been a growing interest in the use of profile assembly in the final presentation of the records. In place of individual records corresponding to each shot point, records are assembled side by side with their datum times brought into coincidence. With the individual trace corrections having been made, reflections should line up both across each record and also from record to record across the profile. The profile thus has a strong visual similarity to a seismic cross-section and also to the corresponding

geological cross-section. This similarity is limited, however, by the fact that no provision is made for migrating reflections when dips are encountered. Such profiles may be on a uniform time scale or a uniform depth scale.

Profiles have the advantage of presenting a large amount of information to the interpreter in a most convenient form. In areas where faults and steep dips occur, it may be possible to identify diffracted events and arrivals which cross the individual records at very steep angles, whilst in areas of very variable reflection quality, the profile facilitates the "carrying-through" of reflections which may not appear on some of the records. The Reynolds Plotter and the Gulf profile printer are examples of two ways of constructing these profiles, and they give records of the type shown at (*b*) and (*d*) respectively in Fig 1. For convenience in viewing, the variable density system has the big advantage that the individual traces can be less than 2 mm wide, so that many records can be assembled on a convenient size of paper (Fig 2).

These changes of method, which will involve some re-organization of seismic interpretational groups, have sprung from various research developments of the last ten years, and their present impetus derives in part from a successful overcoming of some of the instrumental problems involved, with the consequent availability of suitable equipments on a production basis. An unfortunate consequence of the simultaneous development of magnetic recording by a

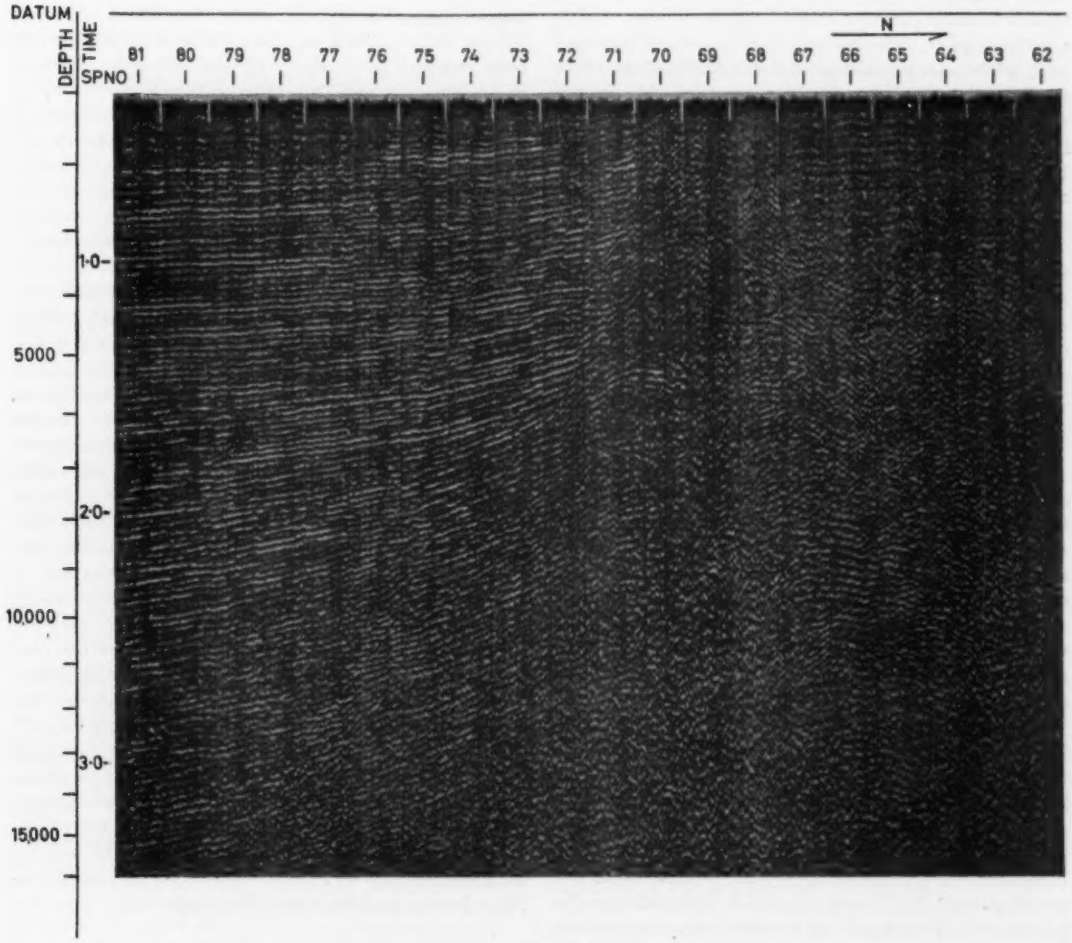


FIG 2

VARIABLE DENSITY PROFILE ACROSS THE SOUTHERN FLANK OF A SALT DOME

number of concerns has been the emergence of basically different systems, so that, generally speaking, magnetic records can be handled only on the same type of equipment as that on which they were made. Thus, apart from the three fundamentally different systems of magnetic recording, the magnetic material may be in the form of disks, continuous tapes, or short lengths of tape mounted on a drum, whilst tape width may range from 2 to 6 inches. Each combination of these features has its own advantages and, whilst one must hope for standardization, there seems to be no immediate prospect of this taking place. Although each oil company can standardize its own equipment, the geophysical contractors may be placed in a rather difficult position, with each oil company requiring records which can be handled in its own playback machines.

This development of wide-band recording with office playback has been described at some length, though by no means completely, since it is the largest single change of recent years in prospecting methods, and one which will affect all those dealing with the results of seismic prospecting.

Other Geophysical Prospecting Methods

In addition to the above standard methods, electrical methods, including telluric current studies, have been used in petroleum prospecting. These methods find particular favour in France, but they are primarily restricted to shallow horizons, and are similar in their general uncertainties to the magnetic and gravimetric methods. Whilst they have given very useful results in places, the recently published case history of the Parentis oilfield [7] is a good illustration of the uncertainties which can arise.

Progress in completely new methods of prospecting has been disappointing, and little information has become available since 1953 on the usefulness of radio and geochemical prospecting methods. The position remains that certain claims made for these methods are viewed with suspicion by most oil companies on theoretical grounds. Whilst there is a pressing need for a method which will indicate the presence of oil at depth by surface measurements, an additional uncertainty has been introduced into such methods by the proof, mentioned earlier, that surface sediments may contain hydrocarbons of recent origin. The presence of these materials near the point of measurement will require either the use of a focusing technique to avoid interference from them, or the elimination of their effects by techniques similar to those used to remove the regional effect in gravity surveys. In the present case, however, estimation of the form of the "regional" effect may require an intensive study of the surface geology. These are further complications of an already difficult problem.

TRENDS IN EXPLORATORY DRILLING

There have been few fundamental changes in drilling techniques, although there is constant improvement in design. Most exploratory drilling is done with rotary, mud-flush equipment, and various techniques, such as the use of jet bits, improved drilling muds, etc., have increased drilling speeds and thereby the tempo of exploration. The use of turbine-bits driven by the drilling fluid on a non-rotating drill pipe has been claimed, particularly by the Russians, to result in greatly-increased drilling speeds. A special application of turbine-bit drilling for exploration may be in the facility with which it is claimed that numerous deviated holes can be drilled from one site. Such a technique would greatly facilitate and cheapen the exploratory drilling of complex structures such as fault traps, where it may be necessary to drill several wells to test a location.

There have been many recent improvements in the design of equipment for marine drilling, and drilling barge units now exist which can literally be towed into a location in up to 75–100 ft of water and start drilling within a period of hours, being entirely self-contained.

Exploratory drilling, with fast rates of penetration in areas of unknown stratigraphy, has been partly responsible for the increased use of electric and radioactive logging of boreholes, to get as much information on the nature of the sediments and of their fluid contents as possible with the minimum of coring and formation testing. This is basically the purpose of "slim-hole" drilling. There is little fundamentally new in the principles of borehole logging, and the instrumental design and interpretation is rather outside the scope of a discourse of trends in exploration. There does not appear to be much prospect that electrical and radiation logging of boreholes will produce any marked changes in exploration methods. The main benefit that accrues from the improvement in such logging is the increased safeguard against missing hydrocarbon accumulations and, more particularly, the provision of more quantitatively accurate information on reservoir characteristics and oil saturations for use in reservoir engineering.

FUTURE DEVELOPMENTS

The only foreseeable development in petroleum exploration as a whole is an increasing dependence on geophysical methods as the search becomes more and more confined to structures having no expression in the surface geology. In geophysics itself, it can safely be said that increasing use will be made of automatic and semi-automatic computing machines for handling geophysical data. Already a number of companies use digital electronic computers, and it can be expected that machines designed particularly for geophysical work will become available.

For seismic prospecting, there is, however, some difference of opinion as to the extent to which mechanization can proceed. This difference is typified by the question, "Will machines ever be able to pick seismic reflections satisfactorily?" Whilst some geophysicists consider that this is a practical possibility, others claim that no two seismic records are alike and that the human operator can more easily allow for all the variable factors involved in making his pick. This latter view appears to be in the majority at the moment.

The use of data-handling machinery is not, of course, a fundamental change of method. Its main advantage is that by speeding up the routine computation, the geophysicist can devote more time to strictly interpretational matters and can carry out more complex computations in an economic time.

The amount of research effort in both geology and geophysics is steadily increasing and it may be expected, or at least hoped, that some further fruits of this research will appear within a few years. It is, however, increasingly clear that, for the seismic methods, more basic information is required on the nature of the propagation of seismic waves through the ground. Both theoretical and practical research on this problem continues, but it may well be some time before any results of direct field application are obtained.

Whilst geophysical exploration maintains a large financial advantage over random drilling as an exploration tool, the cost of geophysical exploration is steadily rising without an equivalent rise in the amount of oil found. The worldwide expenditure on petroleum geophysics in 1956 is estimated at well over £100 million. With expenditure of this order, any research developments, such as magnetic recording, which can increase the quantity of data produced by a field party without any loss in quality, are economically most important. More fundamental improvements of methods could pay an even higher dividend and justify a considerable research investment even though no definite results can be guaranteed from such a programme.

ACKNOWLEDGMENTS

The authors are indebted to the Chairman of the British Petroleum Co. Ltd. for permission to publish this paper. Figs 1 and 2 are reproduced by courtesy of the United Geophysical Company.

References

[1] Germain-Jones, D. T. *J. Inst. Petrol.*, 1953, **39**, 335.
[2] Hanmer, S. *Geophysics*, 1956, **21** (1), 179; *Geophysics*, 1955, **20** (3), 654. Fedynsky, V. V. *Proc. Fourth World Petrol. Congr.*, 1955, **1**, 759. Germain-Jones, D. T. *Geophysical Prospecting*, 1954, **2** (3), 177.
[3] Dyer, W. B. *Oil Gas J.*, 9.7.56, **54** (62), 86.
[4] Woods, J. P. *Geophysics*, 1956, **21** (2), 261.
[5] Olson, R. W. *Oil Gas J.*, 10.1.55, **53** (36), 84.
[6] Pakiser, L. C., and Warrick, R. E. *Geophysics*, 1956, **21** (2), 388.
[7] Vajk, R., and Walton, G. *Geophysics*, 1956, **21** (3), 815.

DISCUSSION

Dr F. R. S. Henson: Modern transport adaptations, logistics of interest to the executive, and new scientific devices and techniques for routine operation appear like milestones of progress in an impressive parade in this paper, leaving little scope for argument because the treatment is largely factual. One must, of course, avoid the impression that oil finding can be entirely mechanized like so many other processes to-day.

This audience does not need to be reminded of the diversity of conditions under which oil accumulations have been found to occur; or of the varied geological, biological, physico-chemical, hydraulic, and structural factors which contribute to each commercial oil pool.

Even the most direct (geochemical) techniques do not lead unequivocally to commercial oil pools. Routine survey methods of all kinds help to locate particular conditions with which such accumulations are often associated, but, owing to their selective approach, they produce partial pictures, like shadows on the wall, which acquire real significance only in their geological context.

On this point I would like to emphasize most strongly the need for team-work in oil finding and for control of exploration as a combined operation, because it is so easy for specialists to pursue independent lines.

The authors have indicated, in applauding geological–geophysical liaison, that belated progress is being made towards collaboration in the field, but it is most marked in the great research laboratories of the oil industry, where teams of geologists, biologists, chemists, physicists, and engineers are attacking the fundamental problems of oil occurrence and oil search.

New techniques which are developed are usually operated by specialists of the hybrid sciences—geophysics, geochemistry, etc.; but the role of co-ordinator and synthesist is that of the geologist, whose special equipment is his basic knowledge of rock formation and deformation, and of the natural history of oil. Consequently the geologist's particular province is the strategic evaluation of prospect areas upon which the appraisal of test locations should depend.

It is, therefore, paradoxical in principle that test locations are often drilled before essential features of the areal geology are known, *e.g.* whether there are favourable conjunctions of source, reservoir, and cover rocks, etc.

In practice, it is recognized that such information may have to be obtained by drilling anyway and that first wells might as well be located where there are at least structural conditions for oil accumulation, offering a gambler's chance of timely revenue.

The research geologist's efforts to improve his equipment of knowledge reveal few highlights of invention or discovery, and perhaps none are to be expected, because he is concerned more with principles than with methods and his lines of enquiry add contributory rather than direct leads to oil finding. The authors have listed some of these, and in further illustration of their diversity I may mention the palæontologist's bio-stratigraphic studies of oil source rock and reef-trap environments,

etc.; the palynologist's iso-botanical lines which may help to delimit shore-lines and other favourable situations; the petrographer's research on porosity-traps; and the work of tectonic experts on rock deformation and the conditions associated with fracture-type oil reservoirs.

Whatever may be the ultimate results of these efforts, none of the work will be wasted, because increased knowledge will be reflected in improved geological judgment which is behind most of the big decisions of exploration policy.

The authors' paper is heavily and justifiably weighted on the side of geophysics, which has been most productive of improved techniques and which is the geologist's best ally.

A potential disadvantage of all stereotyped, routine methods applied to natural phenomena is that they may lose in adaptability what they gain in convenience.

However, the new magnetic tape and playback equipment seems to provide unprecedented flexibility in seismic recording, and the only question I have about it is whether it is not essentially a headquarters re-interpretation tool and whether the geologist may still hope for the party chief's quick approximations, which help him so much in his planning.

It is understood that the variable density profile assembly method illustrated in Fig 2 can be set up in the field. The profiles are so seductively like geological pictures that the authors' warning about effects of migrations is timely.

The structure-finding repertoire of geophysics is now extending to the location of stratigraphic traps in favourable circumstances. Some companies claim that reef-traps can be found by reflection shooting to reveal the discontinuities of stratification associated with them. Presumably conditions favourable for stratigraphic traps of the overlap type could be detected through convergence of strata and I have even heard of a meandering shoe-string sand being accurately mapped by reflection methods. I would like to ask the authors for their views on these three potentialities of the seismographic.

Geophysics has a virtual monopoly of offshore surveys, and a new tool has recently been added. This is the Marine Sonoprobe, which logs sea-floor sediments acoustically down to some 200 ft thickness. Developed first for research on recent sedimentation, it has obvious structure-finding applications in tectonically active areas.

Presumably it would not be possible to use this essentially marine instrument on land for the logging of alluvial and weathered layers which trouble geophysicists?

This, of course, is not the same as the acoustic well-logging device, about which the authors might care to tell us something.

They have dealt briefly with other geophysical logging methods in connexion with exploratory drilling, to which they form an essential adjunct.

The convenience in use of automatic logging has led to almost universal adoption of these methods in areas of high-speed competitive drilling, and this makes for efficiency in geologically well-known territory. But it is necessary to recognize clearly that the place of geophysical–mechanical logging in exploration drilling is similar to that of geophysical methods in ground survey, *i.e.* they give partial pictures only which supplement, but can never substitute full geological information, which may prove to be of critical importance.

One should, therefore, give full weight to any progress towards improved recovery of rock and rock-fluid samples. The use of sidewall coring has certainly extended; new soft-formation and pressure core-barrels have been developed; and the Schlumberger down-hole fluid sampler is undoubtedly significant in these days when refiners are almost as interested in oil qualities as in quantities. New techniques for obtaining approximate reservoir data from cuttings instead of cores revive an old and neglected challenge to the geologist and the driller to get together in improving the quality of cuttings samples, which are so full of information yet so cheap to obtain. The authors might have something to say on the use of well samples for density determinations in connexion with gravity survey.

Reference has already been made to the paradox, arising from the conflict of economic and technical considerations, that all this valuable subsurface evidence, which is really needed to direct exploration, is not usually available until heavy investment in wildcat wells has already been undertaken. Moreover, wildcat well locations selected for structure are not always strategically distributed to give the best spread of information. That is where the early use of stratigraphic slim-hole drilling should come into the picture, as advocated by the authors.

Most companies get round to this phase of exploration sooner or later, because closely-spaced geological observation points are essential at that stage of operations when geological synthesis necessarily supersedes routine survey methods. However, a great deal of the guesswork could be eliminated from geological and geophysical interpretations, and from the location of wildcat wells, if strat-test information could be obtained much earlier.

Ideally, magnetic surveys, which may show variations of total sediment thickness above basement, and gravimetric surveys, which may reveal dominant structural trends, should come first, because together they provide useful impressions of basinal architecture, upon which the location of stratigraphic tests should be based. Drilling of these tests should then precede the slower and more costly seismic and wildcat drilling programmes, which would be affected by the results.

In practice, all sorts of compromises have to be adopted in view of economic and mechanical problems which are not underrated, but, considering past achievements described by the authors, I think drilling experts might be asked if they can foresee the day when strategic slim-hole drilling, say to 10,000 feet, could take its place as a reconnaissance method.

Dr A. T. Dennison: The present magnetic tape systems differ considerably in their details and they are used in different ways by different companies, but in general the quick field interpretation of the seismic data should still be available to the geologist. With some equipments, the playback is carried out by the field party and there is then no problem. With more complex systems, the playback is carried out in the headquarters re-interpretation office, but, in this case, a monitor record is normally obtained in the field which can be used for the field interpretation. In my view the recording system should be arranged in such a way that at least as much information is available to the field party as before, whilst improved information becomes available in the review section.

The reflection seismograph has been successfully used for finding reef structures and various stratigraphic traps. Such problems are usually at the limit of resolution of the seismograph method, although it is difficult to generalize, since the difficulties involved depend not only on the type of trap but also on its depth and the thickness and seismic properties of the rocks involved. I would emphasize, however, that such traps can usually be located only in areas where good quality reflections can be obtained, and even then an experienced geo-

physicist may be required to interpret the results correctly.

Reflection work at sea has not been mentioned in the paper, since there have been no major developments in the period covered; there have, however, been improvements in the details of equipment and techniques. The Marine Sonoprobe is essentially a more powerful form of the conventional echo-sounder, and as such is suitable only for use in water. On land, the fundamental problem is that large energy losses occur in transferring the energy from the acoustic transmitter into the ground, and it is indeed the nature of these losses which has led to the continued use of explosives as the energy source in seismic prospecting. Certainly, in its present form, the Sonoprobe could not be used on land.

The acoustic well logger, or continuous-velocity logger as it is termed, was originally designed as a means of giving the geophysicist detailed information on the velocities of the various strata, and it is being widely used for this purpose. It has also been used for well-correlation purposes, and in some areas is claimed to represent a considerable improvement in this respect on earlier-type logs. More recently, interest has arisen in the possibility of using it to define an oil–water contact in a reservoir rock, and at least one oilfield has been located by this means. Some caution should be used in assessing this claim however. An oil-saturated sand of fairly high porosity will have a velocity perhaps 1000 ft/sec lower than that of the water-saturated sand, the velocity change being mainly due to the gas content of the oil. Before attributing a recorded velocity change to such a cause, however, one must be sure that the change is not due to a change in the lithology at this point and that it is not a spurious effect due to hole diameter changes.

Just as a knowledge of velocity distribution is required for seismic interpretation, a knowledge of rock densities is essential for the interpretation of gravity results, though the amount of detail required will depend on the nature of the survey. Density measurements may be made on well samples if care is taken to obtain representative samples, although it is hoped that the gamma–gamma logging method will provide a quicker method of locating density changes. Development of a borehole gravimeter for this purpose is also being pursued, and this will have the advantage of measuring, in effect, the density of a much larger sample of the ground than other borehole methods.

I. Gillespie: Whilst I have no personal experience of the sidewall corers and fluid samplers mentioned by Dr Henson, many attempts are being made to improve the present-day sample-taking techniques. Any of these improvements which lead to an increase in the amount of information obtained are, of course, of considerable value.

H. C. Lack: At one time the technique was used in seismic work of exploding the charges in the air at a given height from the ground rather than in shot holes. I do not know whether that is in use now or whether it has been given up for the reason that we have heard, that it is difficult by that means to get sufficient energy into the ground. Is there any information on the current situation?

Dr A. T. Dennison: The air-shooting technique, known also as the Poulter method, gave good results in some parts of the U.S.A., but the general impression seems to be that the improvement over other methods was not maintained even over relatively small areas. One of the drawbacks is not the difficulty of getting energy into the ground, but the air-wave created by the explosion. Apart from any difficulties in establishing a large safety zone round the charge, the explosion can be heard over a large area, and this gives rise to many problems in public relations. In theory, one might expect the weight-dropping technique to give similar seismic results with fewer field problems.

A. C. Hartley: It just remains for me to ask you to pass a very hearty vote of thanks to Dr Dennison and to Mr Gillespie for preparing such an interesting paper, and for the way in which they have introduced it.

The meeting then closed with a unanimous vote of thanks to the authors.

INVESTIGATIONS OF TRITIUM BREMSSTRAHLUNG AS A MEANS OF DETERMINING SULPHUR AND TETRA-ETHYL LEAD IN HYDROCARBONS *

By M. M. KANNUNA †

SUMMARY

It is shown that the X-rays which are generated when beta particles from tritium are stopped in a foil containing this isotope are of suitable wavelength for determining the thiophene and tetra-ethyl lead contents of hydrocarbons by absorption measurements.

Using counting techniques to record the X-rays emerging through a cell containing the hydrocarbon, the accuracy of measuring the thiophene content of benzene is 0·033 per cent by weight for a standard statistical deviation of 0·3 per cent. For tetra-ethyl lead in *n*-heptane the corresponding figure is 0·004 per cent by volume.

This sensitivity and accuracy compare favourably with those obtained by other methods of determination.

INTRODUCTION

A RELIABLE method for accurate and rapid estimation of the sulphur and tetra-ethyl lead contents of hydrocarbons is an important requirement in the petroleum industry.

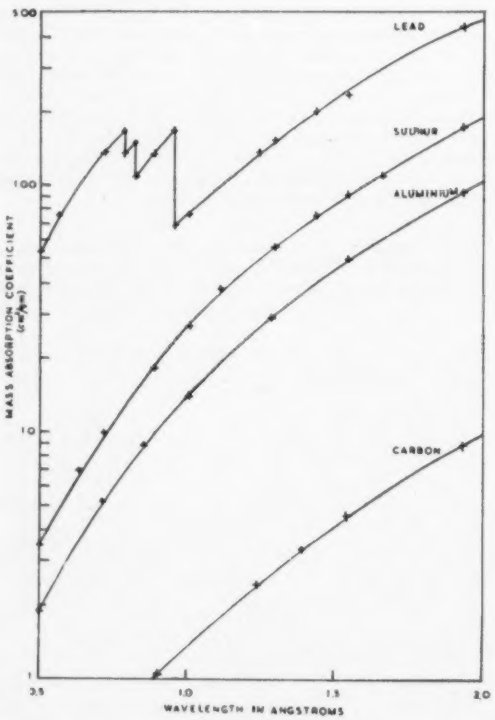


FIG 1

MASS ABSORPTION COEFFICIENTS OF LEAD, SULPHUR, ALUMINIUM, AND CARBON

The absorption of X-rays in the 0·5–5 Å wavelength region is now widely used.[1] Both continuous and line spectra are employed, and the wavelength is chosen to be near the short wavelength side of the absorption edge for the element in question (Fig 1).[2]

X-ray tubes are largely used as the source of radiation,[3–6] but radioactive sources offer the advantages of stability (freedom from power supply variations), compactness, and cheapness. Radioactive sources of radiation in the 0·5–5 Å region must have a long half-life, be available in high specific activity, and be free from other interfering radiations such as gamma radiation or hard beta radiation. So far only iron-55 has been used on a commercial scale.[7]

Another radioactive source of low energy photons is the combination of the continuous X-ray spectrum (bremsstrahlung) and characteristic radiation emitted when soft beta radiation strikes a target.[8–10] In particular, the beta radiation of maximum energy 18 keV emitted by tritium affords a convenient source of radiation of wavelength from 0·68 Å upwards. This source has a half-life of 12·5 years, as compared with the 2·94 years half-life of iron-55. The use of this radiation for sulphur and lead determinations in hydrocarbons is described below.

OUTLINE OF METHOD

The bremsstrahlung from the tritium source is passed through a cell containing hydrocarbons and different concentrations of contaminants. The transmitted intensity of the radiation is measured by means of a Geiger counter. As the intensity varies rapidly with small concentrations of contaminants such as sulphur and lead, a measure of the Geiger count rate gives a measurement of the amount of contaminant present.

Theory

The intensity of a narrow beam of parallel monochromatic X-rays decreases exponentially as it passes through a homogeneous isotropic medium according to the general equation

$$I = I_0 e^{-\mu\rho x} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

* MS received 29 January 1957.

† Higher Teachers Training College, Baghdad. Attached to Isotope Division, A.E.R.E., Harwell, under Baghdad Pact Training Scheme.

where I = intensity of the radiation after absorption;
I_o = intensity of radiation before absorption;
μ = mass absorption coefficient of the absorbing medium;
ρ = density of the medium;
x = thickness of the absorber.

When several absorbing elements are present, the total mass absorption coefficient (μ) is given by

$$\mu = \sum_i \mu_i M_i \quad . \quad . \quad . \quad . \quad (2)$$

where μ_i = mass absorption coefficient of the ith element;
M_i = mass ratio of the ith element.

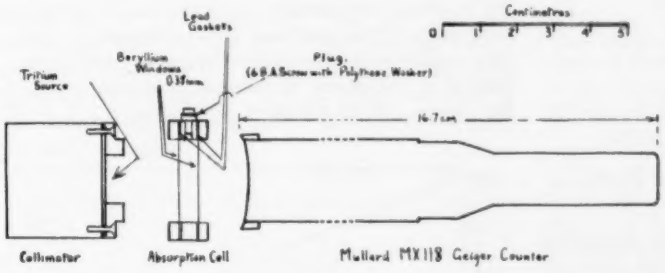


FIG 2
SCHEMATIC DIAGRAM OF APPARATUS
(Courtesy of *The International Journal of Applied Radiation and Isotopes*)

Equation (2) for pure hydrocarbon gives

$$(M_H + M_C)\mu_{HC} = \mu_H M_H + \mu_C M_C$$
$$\text{or } \mu_C . R = \mu_{HC}(1 + R) - \mu_H \quad . \quad .(3)$$

where $R = \dfrac{M_C}{M_H}$ carbon to hydrogen mass ratio.

Similarly, for a mixture of two hydrocarbons, one of which contains a contaminant such as sulphur or lead

$$\mu_1 N = \mu_{12}(1 + N) - \mu_2 \quad . \quad . \quad (4)$$

where μ_{12} = mass absorption coefficient of the mixture;
μ_1 = mass absorption coefficient of the contaminated hydrocarbon;
μ_2 = mass absorption coefficient of the hydrocarbon;

$$N = \frac{\text{concentration by weight of the contaminated hydrocarbon}}{\text{concentration by weight of the pure hydrocarbon}};$$
$$= \frac{\text{mass of contaminated hydrocarbon}}{\text{mass of pure hydrocarbon}}$$

Apparatus

The apparatus is shown schematically in Fig 2. Clamps were used to fix the detector-source separation and the absorption cell was always replaced in the same position relative to source and detector.

Tritium is available in the form of the gas adsorbed on a 200-μg/cm^2 layer of titanium or zirconium which has been vacuum evaporated on to a copper or silver backing. In these experiments a source absorbed on zirconium was reduced in area by means of an iris in a brass diaphragm so that the count rate in the detector was near 20,000/minute with a sample in the absorption cell. The source then had an activity of 114 mC on an area of 1·3 cm^2. The radiations from the source passed through a brass absorption cell with beryllium windows 0·38 mm thick, 23 mm diameter, containing about 1·94 ml of liquid in a 5·09 mm layer. Thin lead washers were used to make a watertight seal. Two small openings in the top were used for filling and they were closed by screws to avoid evaporation during the measurements.

A Geiger counter type MX.118 with an argon filling and a 4-mg/cm^2 mica window was used as the detector. It had a plateau 350 V long with a slope of 3 per cent/100 V, and was operated at 1200 V. Auxiliary counting equipment consisted of a quench unit type 1014A, a scaler type 1009D, E.H.T. unit type 1082B, and a timing unit type 1003E.

Experimental Procedure

Before filling the cell it was first cleaned with acetone and dried. It was then washed three times with some of the sample to be analysed, and then filled carefully through one of the holes by means of a long narrow pipette. Care was taken to avoid trapping air bubbles. The holes of the cell were closed by the screws to prevent evaporation. Excess liquid was wiped from the windows with tissue paper. Temperature measurements were taken throughout; the mean was 18° C and fluctuations were not more than $\pm$1·5° C. With the aid of the timing unit the mean of the total counts occurring in two 5-minute intervals was determined. The counting rate for each measurement was corrected for background and for the artificial dead time of 400 μ sec introduced by the quench unit. Background measurements were made at the beginning and end of each day's experiments.

The characteristic curve was checked at the beginning and twice during the experiments, and both the starting voltage and slope were found to be constant.

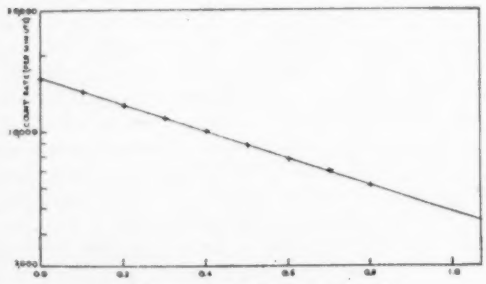
Densities were determined with a gravity bottle.

Aluminium Reference Absorption Curve

The calculations are greatly simplified if the mass per unit area of the different solutions is expressed

in terms of the equivalent mass per unit area of aluminium. To do this a reference absorption curve was obtained.

With the empty absorption cell in place and additional aluminium absorbers the transmitted bremsstrahlung intensity was measured. The range of absorbers used (25–55 mg/cm²) covered the range in counting rate expected from the hydrocarbons plus contaminants. The absorption curve is shown



Thickness of aluminium (mg/cm²)

FIG 3

ABSORPTION OF TRITIUM BREMSSTRAHLUNG IN ALUMINIUM

in Fig 3, and it is seen that the mass absorption coefficient is constant in this region and equal to $48{\cdot}6 \pm 0{\cdot}1$ cm²/g.

Determination of μ_H and μ_C

The absorption of the bremsstrahlung in five pure hydrocarbons, benzene (C_6H_6), toluene (C_7H_8), *o*-xylene (C_8H_{10}), *cyclo*hexane (C_6H_{12}), and *n*-heptane (C_7H_{16}), was measured.

By comparing the count rate obtained with the hydrocarbon of density ρ_{HC} the equivalent mass per unit area of aluminium σ_{Al} is obtained from the aluminium reference absorption curve (Fig 3). Then μ_{HC} is obtained from the relation

$$\mu_{HC} \cdot \rho_{HC} \cdot t = \mu_{Al}\sigma_{Al} \quad . \quad . \quad . \quad (5)$$

where t is the path length of the radiation in the liquid.

Fig 4 shows the relation between R and μ_{HC} $(1 + R)$ (*cf* equation (3)). The slope of this line is equal to μ_C and the intercept with the μ_{HC} $(1 + R)$ axis is μ_H. Values of μ_H and μ_C obtained from the curve are $0{\cdot}9 \pm 0{\cdot}04$ cm²/g and $4{\cdot}21 \pm 0{\cdot}2$ cm²/g respectively.

Determination of μ_S

Thiophene (C_4H_4S) was used as the sulphur-containing hydrocarbon. This was added to *o*-xylene and benzene to give concentrations varying from 0·5 to 5 per cent by weight. The transmitted bremsstrahlung intensity was measured and from this and

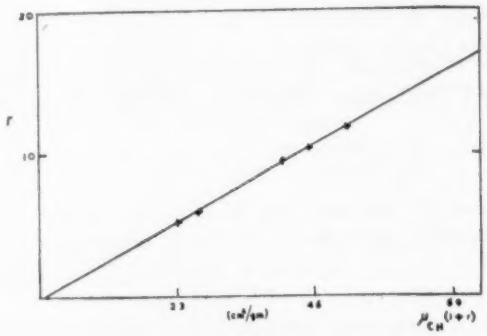
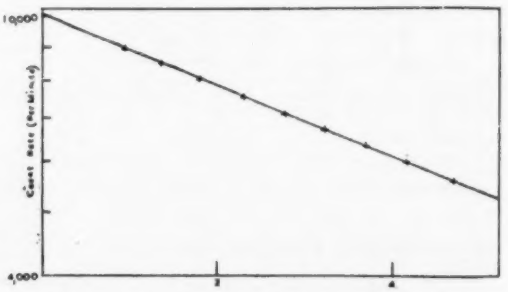


FIG 4

VARIATION OF MASS ABSORPTION COEFFICIENT OF PURE HYDROCARBONS WITH CARBON–HYDROGEN MASS RATIO

the reference aluminium curve the mass absorption coefficients of the mixtures were calculated as above. The variation of transmitted intensity with concentration of thiophene in benzene is shown in Fig 5. By plotting N of equation (4) against μ_{12} $(1 + N)$,



Percentage thiophene in benzene (by weight)

FIG 5

VARIATION OF TRANSMITTED BREMMSTRAHLUNG INTENSITY WITH CONCENTRATION OF THIOPHENE IN BENZENE

μ_1 and μ_2 were determined (Fig 6). μ_S is then obtained from μ_1. Table I shows the values of μ_1, μ_2, and μ_S, and values of μ_2 obtained from the previous measurements of μ_C and μ_H for comparison.

TABLE I

Pure hydrocarbons	Mass absorption coefficient (cm²/g)			
	$\mu_1 = \mu_{CHS}$	μ_S	$\mu_2 = \mu_{CH}$	μ_2 calculated
Benzene . .	31·2 ± 0·4	75·69 ± 1·89	3·98 ± 0·05	3·95 ± 0·02
o-Xylene .	31·78 ± 0·95	76·95 ± 3·85	3·95 ± 0·12	3·90 ± 0·03

Minimum Detectable Concentration of Sulphur in Hydrocarbons

This is a function of the statistical fluctuations in the counting rate, the mass absorption coefficient of sulphur, the density of the base stock, and the

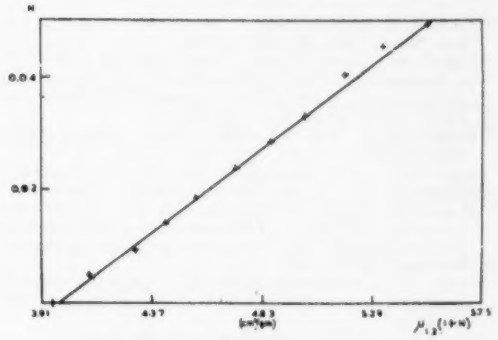
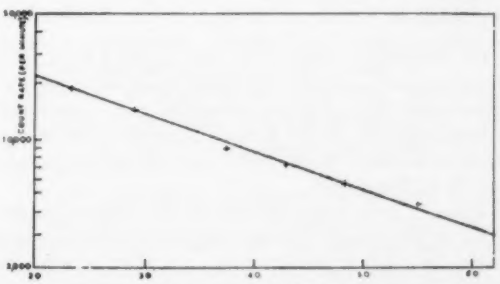


FIG 6

VARIATION OF TOTAL MASS ABSORPTION COEFFICIENT OF THIOPHENE IN BENZENE WITH CONCENTRATION

dimensions of the absorption cell. For the cell dimensions used and assuming that sufficient counts are taken (100,000) to obtain a standard statistical deviation of 0·3 per cent, the corresponding error in the concentration of thiophene in benzene is 0·033 per cent by weight.



Percentage tetra-ethyl lead in *n*-heptane (by volume)

FIG 7

VARIATION OF TRANSMITTED BREMSSTRAHLUNG INTENSITY WITH CONCENTRATION OF TETRA-ETHYL LEAD IN *n*-HEPTANE

Determination of μ_{Pb} *and the Minimum Detectable Concentration*

The mass absorption coefficient of tetra-ethyl lead and then lead were determined in *o*-xylene, benzene, and *n*-heptane in an exactly similar manner. Dilutions from 0·1 to 1 per cent by volume were used. The results for tetra-ethyl lead in *n*-heptane are shown in Figs 7 and 8. Table II summarizes the results.

TABLE II

Pure hydrocarbons	Mass absorption coefficient			
	$\mu_1 = \mu_{CHPb}$	μ_{Pb}	$\mu_2 = \mu_{CH}$	μ_2 calculated
Benzene .	125·49 ± 1·25	193·69 ± 3·87	3·91 ± 0·04	3·95 ± 0·02
o-Xylene .	118 ± 1·7	182 ± 5·5	4·03 ± 0·07	3·90 ± 0·03
n-Heptane .	138 ± 3	214 ± 9·6	3·73 ± 0·08	3·68 ± 0·03

The variation in concentration which corresponds to a statistical deviation of 0·3 per cent in counting rate is 0·004 per cent by volume.

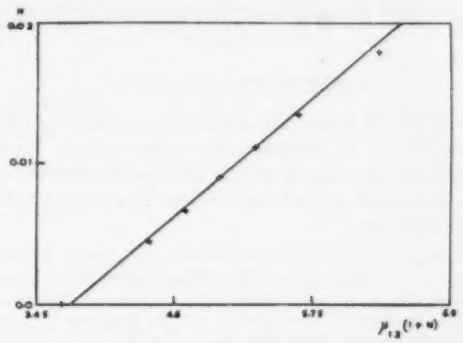


FIG 8

VARIATION OF TOTAL MASS ABSORPTION COEFFICIENT OF TETRA-ETHYL LEAD IN *n*-HEPTANE WITH CONCENTRATION

Effective Wavelength of the Radiation and Comparison with Other Methods

From the mass absorption coefficients determined above, the effective wavelength of the radiations is about 1·5 Å. The sensitivity of the sulphur determinations as deduced from these experiments compares favourably with the results obtained using iron-55 and conventional high voltage X-ray tubes.[11–13]

For lead determinations the use of this source gives a sensitivity almost as good as that obtained with X-ray tubes.[14, 15]

The sensitivity can be increased by increasing the path length of the radiation in the solution, but a source of greater activity would be required. An additional effect of increasing the cell thickness would be to filter out the lower energy radiation and decrease the effective wavelength. This would have little effect for sulphur measurements, due to the constant ratio of the mass absorption coefficients of sulphur and carbon in this wavelength region, but would further increase the sensitivity for lead determinations.

COST OF SOURCE AND AUXILIARY EQUIPMENT

Sources of tritium containing up to 2 curies can be obtained in the form mentioned for £25. It is estimated that 2 curies of tritium in this form gives an X-ray flux equivalent to 2·6 mC of iron-55, after penetrating the empty absorption cell and 40 mg/cm² of aluminium. At the present cost of iron-59 free iron-55 (5*s*/μC) the tritium source is many times cheaper. A further important factor in favour of tritium is the 12·5 years half-life which would necessitate a very infrequent calibration of the apparatus and renewal of the sources.

As a quench unit, power unit, and scaler can be obtained for less than £150 this affords a very cheap and reliable method for rapid routine analysis of the sulphur and tetra-ethyl lead contents of hydrocarbon fuels.

ACKNOWLEDGMENT

The author gratefully acknowledges the suggestion made by J. F. Cameron for using tritium bremsstrahlung as a source of low energy photons and for the assistance and advice received from him in these investigations.

References

[1] Compton, A. H., and Allison, S. K. "X-rays in Theory and Experiment." New York: D. van Nostrand Co., 1936.
[2] Handbook of Chemistry and Physics, 37th Edition. Cleveland, Ohio: Chemical Rubber Publishing Co., 1955–1956.
[3] Birks, L. S., Brooks, E., Friedman, H., and Roe, R. M. *Analyt. Chem.*, 1950, **22**, 1258.
[4] Cranston, R. W., Matthews, F. W. H., and Evans, N. *J. Inst. Petrol.*, 1954, **40** (362), 55–63.
[5] Hughes, H. K. *et al.* *Analyt. Chem.*, 1952, **24**, 1349.
[6] von Hevesy, G. "Chemical Analysis by X-rays and its Application." New York: McGraw-Hill Book Co., 1932.
[7] Hughes, H. K., and Wilczewski, J. W. *Analyt. Chem.*, 1954, **26**, 1889.
[8] Lapp, R. E., and Andrews, H. L. "Nuclear Radiation Physics." New York: Prentice-Hall Inc., 1948.
[9] Leveque, P., Marinelli, P., and Chauvin, R. "Studies and Industrial Application of Bremsstrahlung from the Beta Rays of Yttrium-90." *Peaceful Uses of Atomic Energy*, 1956, **15**, 142.
[10] Reiffel, L., and Humphrey, R. F. "Beta-Ray Excited X-ray Sources." *Peaceful Uses of Atomic Energy*, 1956, **15**, 291.
[11] Victoreen, J. A. *J. appl. Phys.*, 1949, **20**, 1141.
[12] Victoreen, J. A. *J. appl. Phys.*, 1948, **19**, 855.
[13] Victoreen, J. A. *J. appl. Phys.*, 1943, **14**, 95.
[14] Sullivan, M. V., and Friedman, H. *Industr. Engng Chem. Analyt. Ed.*, 1946, **18**, 304.
[15] Hughes, H. K., and Hochgesand, F. P. *Analyt. Chem.*, 1950, **22**, 1248.
[16] Radioactive Materials and Stable Isotopes. Catalogue No. 4, Atomic Energy Research Establishment, Harwell, Jan. 1957.

OBITUARY

CHARLES DABELL

THE unexpected death of Charles Dabell on 28 February at the age of seventy-six removes the last of three brothers who drifted into oilfield duties after some preliminary experience in engineering and water drilling. His early experience on oilfields was obtained in the Grosny fields of Russia, where a number of British companies were successfully operating on well-defined folds in pleasant country. From Russia he transferred his energies for a time to Rumania as pipeline manager for an American Group; but, seeking experience, he next accepted a post as assistant field manager of the Anglo-Persian Oil Company in Persia. He left Persia to find a more salubrious climate and comfortable existence, for in the early days conditions were very primitive and unpleasant. Transferring his energies again to Russia, he was one of those engaged in the early development of the Maikop oilfield, where, due to the striking of a 10,000-barrel gusher at shallow depth, there arose a scramble for plots at ever-increasing prices. This oilfield was located in delightful foothill, forested country, which in the spring was a picture of flowering shrubs and ground plants. Brigands alone were a handicap, and many Company treasurers were relieved of the pay packets they were carrying by footpads who sheltered in the woods. Following a short return to the Caucasus, he became engaged on war services until world war I came to an end.

On restoration of peace he was engaged for a time in advising a London Group on their oil activities, but was eventually induced to accept the post of assistant general manager of the British Controlled Oilfields in Venezuela under that kindly and efficient man, the late F. G. Rappoport.

Dabell's next appointment was in Patagonia, another of those God-forsaken semi-arid oilfield regions swept by violent sandstorms: so after a time he joined his brother in the more pleasant surroundings of Egypt.

Charles Dabell, like his twin brother, was always a cheerful, bright companion, and he delighted in recounting his amusing if often alarming experiences in the inhospitable lands to which he was despatched. Wherever he went and whatever the task imposed upon him, he never lost those high spirits and that boundless energy that infected his colleagues to no small extent. This was a valuable attribute of those engaged in pioneering when unprovided with all those wonderful aids which now ensure quick transport and comfortable amenities that were previously unthought of.

Charles Dabell was one of those who agreed to become a member of the Institution of Petroleum Technologists prior to its foundation, and has been a frequent contributor to discussions at meetings.

A. B. T.

THE INSTITUTE OF PETROLEUM

ANNUAL REPORT

For the Year Ended 31 December 1956

GENERAL

Council is gratified, once again, to be able to report a continued rise in the membership. The total has passed the 3500 mark for the first time.

New Building

Plans for the conversion of No. 61 New Cavendish Street into the Institute's new home have gone steadily ahead.

Good progress has been made towards the target for the Building Fund. The response has been most encouraging, both from the corporate members and member companies. Council very much appreciates the generous assistance received to date.

The work of rehabilitation started in the autumn and the new building, which is to be called "The Institute of Petroleum," should be finished in the early autumn 1957.

In the early stages of the work the need for additional restoration of the foundations was revealed, and attention is drawn to the fact that additional money is required and that this fund remains open to receive it.

Honours

The Council of the Institute offer their congratulations to the following members of the Institute who were honoured by Her Majesty the Queen during 1956 :

Sir Frederick Godber, F.Inst.Pet., who was made a Baron and took the title of Lord Godber of Mayfield.

H. S. Gibson, C.B.E., F.Inst.Pet., a past-president of the Institute, who was granted a Knighthood.

R. E. Hales, M.Inst.Pet., who was awarded a C.B.E.

General Meetings

Nine General Meetings were held during the year, and attendances were good. The papers presented dealt with the science of petroleum in various aspects.

Annual Dinner

The Right Honourable Aubrey Jones, M.P., was the guest of Honour at the Annual Dinner of the Institute, held at Grosvenor House in February. There were nearly 1300 members and guests present.

Summer Meeting

Another most enjoyable Summer Meeting was held in June, when 140 members and their ladies met in Torquay for the annual three day meeting. The theme of the papers presented and discussed was "Essential Factors in the Future Development of the Oil Industry."

Awards

Mr H. Hyams was awarded the Eastlake Medal in October.

Studentship

Mr R. E. Gibbons was awarded the Institute's Annual Prize at the Imperial College of Science and Technology, and Mr G. B. Fulford the Institute's Scholarship at the University of Birmingham.

Benevolent Fund

Assistance was continued during the year for two applicants.

Aviation Products Data Committee

The Lubricating Oils Data Sheets and new and revised Fuels Data Sheets were issued early in the autumn of 1956. No further work is planned at present.

Branches

All Branches of the Institute have had an active and successful year. In November 1956 Council agreed to the application that a new Branch, to be known as the Essex Branch, be formed in the Coryton area. The inaugural meeting of this Branch took place on 18 January 1957. Officers of the London and South-Eastern Branches have welcomed the formation of this new Branch, because inadequate transport facilities make it difficult for people in the Coryton area to take part in the activities of the adjacent Branches.

The Northern Branch, as a member of the Manchester Federation of Scientific Societies, arranged the

Federation's annual symposium in April 1956, when the subject was "Lubrication." The symposium was a great success, and many tributes were paid to its organization, for which the Northern Branch was responsible.

By-Laws Committee

A considerable amount of work was done during the year in connexion with the liability of the Institute in respect of rates (a not inconsiderable amount when the Institute's new premises are occupied).

Possible formal changes in the Institute's constitution, which might conceivably affect rate liability, have been discussed with our legal advisers, and the matter was still under consideration at the end of the year.

The committee made certain comments on the first draft of a Bill which is being put forward to modify the Scientific Societies Act, 1843, and such comments, after approval by Council, were forwarded to the sponsors of the Bill, which, as modified in its second draft, is now more in accordance with the Institute's views.

Economics and Operations Group

The current session of the Economics and Operation Group includes papers which have already been read and received with interest. In the part of the session which concluded at the end of 1956 the Group heard three papers respectively on the subjects of "Enquiry after Accidents," "Techniques of Forward Estimating Oil Demand," and "The Place of Automatic Equipment in Marketing Operations." In each case the talks were followed by lively discussion.

Education Committee

The Education Committee has been reviewing the ways in which the Institute of Petroleum might be of assistance in regard to the educational needs of the petroleum industry. There seems to be general agreement that the Institute should not be an examining body, but suggestions have been made on how the Institute might give guidance and help to educational bodies in regard to their syllabuses, and might act as a clearing house for ideas and suggestions which might be passed to the appropriate college, university, or examining body. These latter proposals are receiving further consideration.

Engineering Committee

The Safety Codes continue to be an important feature of the work of the Institute which is of considerable practical value to the various sections of the Petroleum Industry.

The "Refining Safety Code" and the revised "Electrical Code" were published during the year. The "Drilling and Production Safety Code" was completed and sent to the printers in the late autumn.

A Tanker Sub-Committee has been formed to prepare a "Code of Safety Practice for Tankers." A number of shipping companies as well as the oil companies operating tanker fleets have nominated representatives to serve on this Sub-Committee. Another new Sub-Committee, under the Chairmanship of the Chairman of the Marketing Sub-Committee, has been organized to draft a code on "Siting of Aviation Facilities at Airports." This will not impinge on operational matters, but will be a safety engineering code.

As is customary, various requests for information and advice on engineering subjects were received. These were dealt with satisfactorily.

Publications

One of the most important books yet published by the Institute was issued in October, this being "Essential Factors in the Future Development of the Oil Industry." In contained the papers read at the Summer Meeting, with a full account of their discussion, and a special effort was made to make it available in the shortest time after the meeting.

The *Journal* and the *IP Review* were, as usual, published in regular monthly parts, and in size were about the same as in 1955. In circulation, however, there has been a gratifying increase, due partly to the increase in membership but also to subscriptions from non-members.

With the completion of the 1956 volume, the *IP Review* had been in existence for ten years.

The publication of Safety Codes is referred to above.

The 15th edition of "Standard Methods for Testing Petroleum and its Products" made its appearance in February, and a third reprint of "IP Engine Test Methods for Rating Fuels" also became necessary. The opportunity was taken to make slight amendments pending a complete revision later.

Library

The value of the Library to the members was considerably enhanced during 1956 by the publication of The Library Catalogue, which was made available to them free of cost. The use made of the Library by non-members as well as by members increased considerably in comparison with 1955.

Research

The work of the Hydrocarbon Research Group and the co-operation with the Medical Research Council on biological activity of petroleum fractions has continued.

Standardization Committee

Work has continued throughout the year on the revision and extension of test methods as necessary,

and the 16th edition of "Standard Methods" is due for publication early in February 1957.

The Committee has co-operated actively with the British Standards Institution, the A.S.T.M., and also with standardizing bodies in other countries, in regard to test methods for petroleum products.

Staff

The Institute continues to be well served by its regular staff and Council has again recorded its appreciation of the loyal, willing, and most efficient service given by all concerned.

MEMBERSHIP

Details of Membership as at 31 December 1956 :

	Total 31 Dec. 1955	Changes during 1956						Total Dec. 31 1956
		New	Transferred to	Resigned	Deceased	Transferred from	+ or −	
Honorary Members	2	—	—	—	—	—	—	2
Honorary Fellows	5	—	—	—	—	—	—	5
Members	613	44	2	26	5	3	+ 12	625
Fellows	697	29	8	16	4	1	+ 17	714
Associate Members	853	41	—	45	1	5	− 10	843
Associate Fellows	1122	162	8	42	1	4	+123	1245
Students	76	17	—	13	—	5	− 1	75
Totals	3368	293	18	142	11	18	+140	3508
Member Companies	184	10	—	5	—	—	+ 5	189

DEATHS

It is with regret that the following deaths during 1956 are recorded :

L. E. S. Ambrose (AM)
A. W. G. Bleeck (M)
A. F. Dabell (F)
R. V. Durran (AF)
E. G. Godfrey (M)
E. L. De Golyer (F)
C. W. Knighton (M)
G. R. Llewellyn (M)
Dr F. Roth (F)
R. H. Sperling (M)
O. Thornycroft (F)

A. F. Dabell had been a member for over forty years, E. L. De Golyer for thirty-eight years, and A. W. G. Bleeck, G. R. Llewellyn, and R. H. Sperling had been members for over thirty years.

By Order of the Council,

C. CHILVERS,
Honorary Secretary

THE INSTITUTE

(A Company limited by Guarantee

BALANCE SHEET AS

1955 £	£		£ s. d.	£ s. d.	£ s. d.
		Capital of the Institute under Bye-Laws 36, 44, and 45 :			
		Life Membership Fund—	£ s. d.		
		As at 31 December 1955	1,008 17 9		
		Add Receipts during 1956	95 5 3		
	1,009			1,104 3 0	
		Entrance and Transfer Fees—			
		As at 31 December 1955	7,718 3 9		
		Add Receipts during 1956—			
		Entrance Fees	363 6 0		
		Transfer Fees	6 6 0		
	7,718			8,087 15 9	
		Donations—			
	326	As at 31 December 1955		326 5 0	
	9,053			9,518 3 9	
	291	*Less* Net loss on Sale of Investments brought forward		291 9 9	
8,762					9,226 14 0
5		**T. C. J. Burgess Prize Fund**			5 0 0
1,702		**General Reserve (previously War Contingencies Reserve)**			1,702 0 11
		Revenue Account :—			
		As at 31 December 1955		32,661 0 10	
		Add Surplus for year		6,819 10 2	
32,661					39,480 11 0
—		**Building Fund Account**—per attached account			19,982 7 5
		Subscriptions Received in Advance :			
		Members' Subscriptions for 1957		790 9 0	
		Members' Subscriptions for 1958		13 9 0	
		Members' Subscriptions for 1959		12 12 0	
		Members' Subscriptions for 1960		4 4 0	
		Member Companies' Subscriptions for 1957		151 0 0	
		Journal Subscriptions for 1957		1,532 1 3	
		Journal Subscriptions for 1958		45 14 1	
		Journal Subscriptions for 1959		5 9 6	
3,143					2,554 18 10
		Current Liabilities and Provisions :			
	350	Provision for Pension		350 0 0	
	6,788	Sundry Creditors and Accrued Charges		5,449 1 8	
	66	World Petroleum Congress		558 17 11	
		Entertainment Account—			
		As at 31 December 1955	108 5 11		
		Add Excess of Receipts over Expenditure during year to date	258 5 1		
	108			366 11 0	
7,312					6,724 10 7
		Sum Set Aside for Grants to Branches and Students' Section—unallocated :			
		Balance, as at 31 December 1955		164 3 0	
		Add Amount set aside during year		650 0 0	
				814 3 0	
164		*Less* Grants made during year		740 0 0	
					74 3 0
£53,749					£79,750 5 9

AUDITORS' REPORT TO THE MEMBERS

We have examined the above Balance Sheet and annexed Revenue Account and report that we have obtained all the In our opinion, proper books of account have been kept by the Institute, so far as appears from our examination of those best of our information and according to the explanations given to us, the accounts give the information required by the affairs at 31 December 1956, and the Revenue Account gives a true and fair view of the revenue for the year ended on that

88 LEADENHALL STREET,
LONDON, E.C.3.

1 *March* 1957.

OF PETROLEUM

and not having a Share Capital)

AT 31 DECEMBER 1956

1955 £	£		£ s. d.	£ s. d.
		Leasehold Premises :		
19,998		Cost of acquisition		19,998 10 0
		Office and Library Furniture :		
		At valuation, being Net Amount standing in the Company's Books at 1st July, 1948, *less* Sales	221 10 8	
		At cost	2,778 18 9	
			3,000 9 5	
		Less Aggregate Depreciation	1,332 11 8	
1,841				1,667 17 9
		Current Assets :		
	6,186	Stock of Publications in hand, as certified by the General Secretary	4,705 16 3	
	435	Stock of Envelopes (for dispatch of *Journals*)	322 0 5	
		Sundry Debtors and Payments in advance, including Income Tax recoverable £5,840 13 1		
		Less Provision for Doubtful Debts — — —		
	6,453		5,840 13 1	
	—	Members' subscriptions in arrear (not valued)	— — —	
	—	Member Company's Subscription in arrear	250 0 0	
	408	Cash on Deposit with Post Office Savings Bank	418 0 9	
		Cash at Bank—		
	14,403	Deposit Account £18,402 14 3		
	3,317	Current Account 7,195 14 10		
	108	Entertainment Account 366 11 0		
			25,965 0 1	
	600	Cash in Hand	600 0 0	
31,910				38,101 10 7
—		**Assets Held on Account of the Building Fund**—per contra		19,982 7 5
£53,749				£79,750 5 9

OF THE INSTITUTE OF PETROLEUM

information and explanations which to the best of our knowledge and belief were necessary for the purposes of our audit. books. The Balance Sheet and Revenue Account are in agreement with the books of account. In our opinion, and to the Companies Act, 1948, in the manner required, and the Balance Sheet gives a true and fair view of the state of the Institute's date.

SMITH & WILLIAMSON,
Chartered Accountants.
Auditors.

THE INSTITUTE

(A Company limited by Guarantee

REVENUE ACCOUNT FOR THE

1955 £	£		£ s. d.	£ s. d
		To **Administrative Expenses :**		
11,420		Staff Salaries and National Insurance	12,305 8 4	
1,056		Staff Pension Scheme Contributions	1,211 13 11	
12,476			13,517 2 3	
6,684		*Less* Applicable to Publications	7,134 6 3	
5,792				6,382 16 0
	1,230	Printing and Stationery	1,606 16 2	
	969	General Postages	1,083 7 1	
	286	Telephones, Cables and Travelling Expenses	362 4 6	
	2,485		3,052 7 9	
	828	*Less* Applicable to Publications—one-third	1,017 9 3	
1,657				2,034 18 6
74		Audit Fee	94 10 0	
174		General Expenses	198 10 10	
46		Insurance	66 18 2	
				359 19 0
7,743				8,777 13 6
		„ **Establishment Expenses :**		
	2,579	Rent	2,942 11 5	
	590	Cleaning, Lighting and Heating	577 17 10	
	38	Repairs and Maintenance	32 15 4	
	3,207		3,553 4 7	
	782	*Less* Applicable to Publications	777 13 3	
2,425				2,775 11 4
		„ **Meetings :**		
470		Hire of Hall, Preprints, Reporting, etc.		436 2 9
650		„ **Sum Set Aside for Grants to Branches and Students' Section**		650 0 0
—		„ **Miscellaneous Expenses in Connection with the Building Fund**		130 16 9
		„ **Sundries :**		
		Library Expenses	268 4 0	
		Legal Expenses	10 10 0	
		Subscriptions to Societies	81 0 4	
		Scholarship Awards	100 0 0	
		Depreciation of Furniture (10%)	185 6 0	
662				645 0 4
1,189		„ **Loss on Sale of Investments Held on Revenue Account**		— — —
		„ **Publications Revenue Account :**		
—		Deficit for year		574 16 3
10,994		„ **Balance, being Surplus Revenue for Year**		6,819 10 2
£24,133				£20,809 11 1

OF PETROLEUM

and not having a Share Capital)

YEAR ENDED 31 DECEMBER 1956

1955 £		£	*s.*	*d.*
10,925	By **Members' Subscriptions received for 1956**	11,248	19	0
185	„ **Members' Subscriptions in Arrear, received during year**	116	15	0
8,746	„ **Member Company Subscriptions received for 1956**	8,725	4	6
20	„ **Special Subscription**	20	0	0
849	„ **Interest Received (Gross)**	698	12	7
	„ **Publications Revenue Account :**			
3,408	Surplus for year	—	—	—
£24,133		£20,809	11	1

PUBLICATIONS REVENUE ACCOUNT FOR THE YEAR ENDED 31 DECEMBER 1956

	£	s.	d.		£	s.	d.
To Stock in Hand at 1 January 1956	6,186	3	6	By Advertising	15,844	10	11
,, Dispatch Expenses	1,497	16	9	,, Standard Methods (15th Edition)	4,574	5	0
,, Standard Methods (15th Edition)	1,517	2	10	,, Journal	3,651	5	7
,, Journal	7,883	13	3	,, Glossary	28	7	6
,, IP Review	8,216	7	10	,, IP Review	445	0	5
,, IP Engine Test Methods for Rating Fuels	43	16	2	,, Role of Petroleum in Modern Transport	97	7	6
,, Essential Factors in the Future Development of the Oil Industry	703	9	1	,, Modern Petroleum Technology (Vol. 2)	664	0	0
,, Electrical Code	252	18	10	,, Reviews of Petroleum Technology	684	5	0
,, Other Publications	55	10	2	,, Petroleum Measurement Manual	294	2	0
,, List of Members	520	13	0	,, Handy Tables	525	16	0
,, Abstracts	250	5	6	,, IP Engine Test Methods for Rating Fuels	190	0	0
,, Publicity	376	3	11	,, Marketing Code	343	18	0
,, Library Catalogues	362	6	10	,, Significance of Properties of Petroleum Products	174	13	6
,, Refining Code	505	2	6	,, Post-War Expansion of U.K. Petroleum Industry	51	0	0
,, Salaries, National Insurance, and Pension Scheme Contributions	7,134	6	3	,, Other Publications	554	19	0
,, Proportion of Administrative Expenses	1,017	9	3	,, Electrical Code	1,178	19	6
,, Proportion of Establishment Expenses	777	13	3	,, Tables for Measurement of Oil (British Edition)	975	15	0
,, Bad Debts written off	35	11	6	,, Tables for Measurement of Oil (Metric Edition)	739	15	0
				,, Essential Factors in the Future Development of the Oil Industry	424	16	0
				,, Library Catalogues	32	12	6
				,, Refining Code	580	9	6
				,, Stock in Hand at 31 December 1956	4,705	16	3
					36,761	14	2
				,, Balance, being Deficit for year carried to Revenue Account	574	16	3
	£37,336	10	5		£37,336	10	5

BUILDING FUND ACCOUNT FOR THE YEAR ENDED 31 DECEMBER 1956

	£	s.	d.	£	s.	d.		£	s.	d.
To Cost of Work Executed				10,466	18	0	By Donations	29,704	10	10
,, Balance at 31 December 1956 :							,, Interest on Loan to Royal Burgh of Dumbarton	620	7	3
Represented by—							,, Interest on Bank Deposit Account	124	7	4
Loan—Royal Burgh of Dumbarton	18,000	0	0							
Cash at Bank on Current Account	1,650	4	8							
Tax Recoverable on Loan Interest	213	0	10							
Loan Interest Receivable (Gross)	119	1	11							
				19,982	7	5				
				£30,449	5	5		£30,449	5	5

HYDROCARBON RESEARCH GROUP

Revenue Account for the Year ended 30 September 1956

	£	s.	d.	£	s.	d.
To **Stock in Hand of "Applied Mass Spectrometry"**				234	0	0
„ **Grants:**						
King's College	1,000	0	0			
University of Oxford	900	0	0			
University of Birmingham	400	0	0			
University of Bristol	1,000	0	0			
Queen Mary College	1,672	0	0			
University of Liverpool	500	0	0			
University of Cambridge	600	0	0			
				6,072	0	0
„ **Honoraria**				420	0	0
„ **General Expenses**				21	12	2
„ **Wages**				350	0	0
„ **Expenses** re—						
Applied Mass Spectrometry	213	5	0			
Molecular Spectroscopy	1,133	10	6			
				1,346	15	6
„ **Balance**, being Surplus for year				826	2	5
				£9,270	10	1

	£	s.	d.
By **Voluntary Contributions from Members of the Group**	8,000	0	0
„ **Sales of "Applied Mass Spectrometry"**	495	12	0
„ **Sales of "Molecular Spectroscopy"**	393	12	1
„ **Sale of Technical Reports**	2	5	0
„ **Stock in Hand of "Molecular Spectroscopy"**	379	1	0
	£9,270	10	1

Notes:

(i) For convenience in administration, the Accounts of the Group are closed as at 30 September each year.

(ii) The Group are now liable to bear all losses incurred in connection with their publications.

Statement of Funds at 30 September 1956

	£	s.	d.	£	s.	d.
Sundry Creditor—The Institute of Petroleum				243	12	0
Revenue Account:						
As at 30 September 1955	1,395	1	10			
Add Surplus for year	826	2	5			
				2,221	4	3
				£2,464	16	3

	£	s.	d.
Stock in Hand of "Molecular Spectroscopy"	379	1	0
Cash at Bank on Current Account	2,085	15	3
	£2,464	16	3

We have examined the above Revenue Account and Statement of Funds with the books and vouchers of the Group and find them to be in accordance therewith.

Cunard House,
88 Leadenhall Street,
London, E.C.3.
1 *March* 1957.

Smith & Williamson,
Chartered Accountants.
Auditors.

CARCINOGENICITY RESEARCH FUND

Statement of Funds as at 31 December 1956

	£ s. d.	£ s. d.		£ s. d.
Balance of Sum Received from the Petroleum Board (during 1947):			**Cash at Bank on Current Account**	304 0 8
As at 1 January 1956	450 0 0			
Less Payment to University of Birmingham, for research	147 3 0			
		302 17 0		
Accumulated Net Income:				
As at 1 January 1956		1 3 8		
		£304 0 8		£304 0 8

We have examined the above Statement of Funds with the books and vouchers of the Fund and find it to be in accordance therewith.

CUNARD HOUSE,
88 LEADENHALL STREET,
LONDON, E.C.3.
1 *March* 1957.

SMITH & WILLIAMSON,
Chartered Accountants.
Auditors.

CADMAN MEMORIAL FUND

Income and Expenditure Account for the Year ended 31 December 1956

	£ s. d.	£ s. d.		£ s. d.
To **Balance as at 31 December 1956:**			By **Balance at 31 December 1955**	3,399 0 2
Cash at Bank on Deposit Account	500 0 0		**Interest Received (Gross)**	98 16 0
Cash at Bank on Current Account	267 16 2			
£2,730 3% Savings Bonds 1965/75 (Market Value—£2,034)	2,730 0 0			
		3,497 16 2		
		3,497 16 2		£3,497 16 2

We have examined the above Income and Expenditure Account with the books and vouchers of the Fund and find it to be in accordance therewith.

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LONDON, E.C.3.
1 *March* 1957.

SMITH & WILLIAMSON,
Chartered Accountants.
Auditors.

BENEVOLENT FUND

Income and Expenditure Account for the Year ended 31 December 1956

1955 £		£ s. d.	£ s. d.	*1955* £		£ s. d.
105	To **Grants Paid**		105 0 0	*3,269*	By **Balance at 31 December 1955**	3,420 12 2
—	,, **Cheque Book**		4 0	*181*	,, **Subscriptions and Donations received during year**	204 18 6
	,, **Balance at 31 December 1956:**			*76*	,, **Interest Received (Gross)**	88 3 6
	Represented by—					
	Sundry Debtors	35 17 0				
	Cash at Bank on Deposit Account	900 0 0				
	Cash at Bank on Current Account	622 13 2				
	£1,550 2½% Defence Bonds	1,550 0 0				
	£500 3½% Defence Bonds	500 0 0				
3,421			3,608 10 2			
	(Market Value of Investments—£2,050)					
£3,526			£3,713 14 2	*£3,526*		£3,713 14 2

We have examined the above Income and Expenditure Account with the books and vouchers of the Fund and find it to be in accordance therewith.

CUNARD HOUSE,
88 LEADENHALL STREET,
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1 *March* 1957.

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THE INSTITUTE OF PETROLEUM

FORTY-FOURTH ANNUAL GENERAL MEETING

THE Forty-fourth Annual General Meeting of The Institute of Petroleum was held at 26 Portland Place, London, W.1, on 24 April 1957, the chair being taken by A. C. Hartley, C.B.E., F.C.G.I., B.Sc., a vice-president.

The notice convening the meeting was read by the General Secretary, who also read the minutes of the Forty-third Annual General Meeting. The latter were confirmed and signed as a correct record.

The chairman announced that Lord Geddes, the President, was in Canada on business and had cabled his regrets at being unable to be present.

ELECTION OF OFFICERS FOR THE SESSION 1957–58

President

The chairman announced that the Council had unanimously nominated the Rt. Hon. Lord Geddes to serve a second year of office as President, and he had much pleasure in proposing that from the chair.

The proposition was seconded by A. J. Ruthven-Murray and carried unanimously.

Vice-President

H. Hyams having been nominated by Council to serve as a vice-president for a term of three years, a proposition to this effect was made by the chairman and seconded by J. R. Moore. This was carried unanimously.

Council

The General Secretary announced that as a result of the ballot for council the following had been declared elected: W. S. Ault, F. Morton, K. E. W. Ridler, D. L. Samuel.

Honorary Treasurer

E. Le Q. Herbert proposed and E. C. Masterson seconded that G. H. Coxon be re-elected Honorary Treasurer for the session 1957–58. This proposition was carried unanimously.

Honorary Secretary

It was proposed by A. J. Goodfellow and seconded by F. L. Garton that C. Chilvers be re-elected Honorary Secretary for the year 1957–58. This was carried unanimously.

Ex-Officio Members of Council

The following were nominated as ex-officio members of Council: S. A. Berridge, A. S. Brooman, A. H. Chatting, J. C. Jewell, L. S. Thornes, J. C. Wood-Mallock. A. C. Hartley proposed and F. L. Garton seconded that these be elected and the motion was carried unanimously.

MEMBERS ELECTED OR TRANSFERRED

A list of Honorary Members, Honorary Fellows, Members, Fellows, Associate Members, Associate Fellows, and Student Members elected or transferred during 1956 was tabled in conformity with By-law 52.

REPORT OF COUNCIL

C. Chilvers, Honorary Secretary, presenting the report of Council for the year 1956–57, said: I am very glad to be able to report another year of steady progress. Our membership has, in fact, passed the 3500 mark. I need hardly say that that is not the target figure by any means, and I am quite sure that there are many people still to come into the membership of the Institute. I think that we can certainly look forward to a membership of nearer 5000 than 3500.

Probably the most outstanding activity during the year was the new building. The Building Fund itself has made very good progress, and there has been a very generous response both from members and from Member-Companies. The Council very much appreciates the help which it has received. The work of reconstruction has proceeded well. There have been some slight delays, as often occurs in this sort of thing, but we hope to be in the building during the coming autumn.

The Council unanimously awarded the Eastlake Medal to Harry Hyams as a token of appreciation of the value of his services to the Institute as a Member of Council and also in many spheres over quite a number of years.

The Branches of the Institute, to which Council attach a great deal of importance, have all had a successful year. A new Branch was formed during the year, the Essex Branch, in the Coryton area, and the Northern Branch organized a very successful Symposium on Lubrication, on behalf of the Manchester Federation of Scientific Societies.

The Economics and Operations Group has had a very successful session, and the Engineering Commit-

tee has continued its activities. The " Refining and Safety Code " and the revised " Electrical Code " were both published during the year, and the " Drilling and Production Safety Code " was put in the hands of the printers. Work is also progressing on two further codes; one, " Safety Practice for Tankers," and the other, " Siting of Aviation Refuelling Facilities at Airports " (Airfield Supplement of IP Marketing Code). I think these codes are a very important part of the Institute, and they have attracted quite a good deal of attention.

On the Publications side very important and very useful work has been done, and there was quite an achievement in producing the " Essential Factors in the Future Development of the Oil Industry," the record of the very successful Summer Meeting last year. That publication was produced by October.

The *Journal* and the *IP Review* continued in their regular monthly parts, and there was quite a gratifying increase in circulation. " Standard Methods for Testing Petroleum and its Products " continued its regular appearance. All these publications speak for themselves in regard to the work of our editorial people.

Standardization still occupies an important part, and under the chairmanship of F. L. Garton, the Standardization Committee continued its work in this field.

There was a continuation of the co-operation with the British Standards Institution, and with other standardization bodies.

Finally, I would pay my personal tribute, and also the tribute of Council, to the regular staff of the Institute. We are very well served by them, and those of us closely concerned with the work of the Institute know how much we owe to them.

I have much pleasure in proposing the adoption of the Report.

The proposition was seconded by A. H. Chatting and carried unanimously.

ACCOUNTS

The Chairman said that T. W. Mathias, Chairman of the Finance Committee, very much regretted that he was not able to be present, but he had sent the following statement for presentation to the meeting :

The year 1956 has again been a successful one, and you will see that the surplus of the year is just under £7000. In view of the continuing rise in costs generally, this is a very satisfactory result, and attention is directed to the fact that in spite of this continued rise, the whole of the Institute's expenditure during 1956 has risen only by some £1400, notwithstanding that the Institute's activities continue to grow, year by year. This increase figure also contains an item of Ground Rent for the new premises, totalling approximately £500.

On the Revenue side, it is again pleasant to report that Members' subscriptions increased during the year, and that the figure for Member-Companies has remained steady. A special drive to increase the membership under this latter category during 1957 has proved most successful, and the 1957 figure should show a considerable increase.

It will be noticed that the Publications Revenue Account showed a deficit during the year of £574, against a surplus last year of £3400. This account varies considerably from year to year. In 1955 a record number of books were published, and the two special numbers of the *IP Review* made a difference of over £1000 in the advertisement figures. Taken all round, the Publications figures are considered satisfactory.

The Chairman proposed the adoption of the accounts, and H. Hyams, in seconding the adoption, expressed the gratitude of the chairman of the Finance Committee and his colleagues for such a satisfactory credit balance in the Revenue Account for the year. The adoption of the accounts was carried unanimously.

AUDITORS

H. Hyams proposed and A. J. Goodfellow seconded the motion that Messrs Smith and Williamson be our appointed auditors at a remuneration to be agreed by Council. This was unanimously approved.

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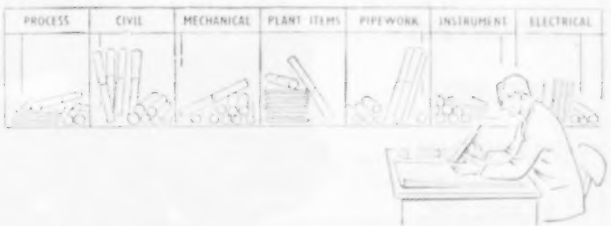

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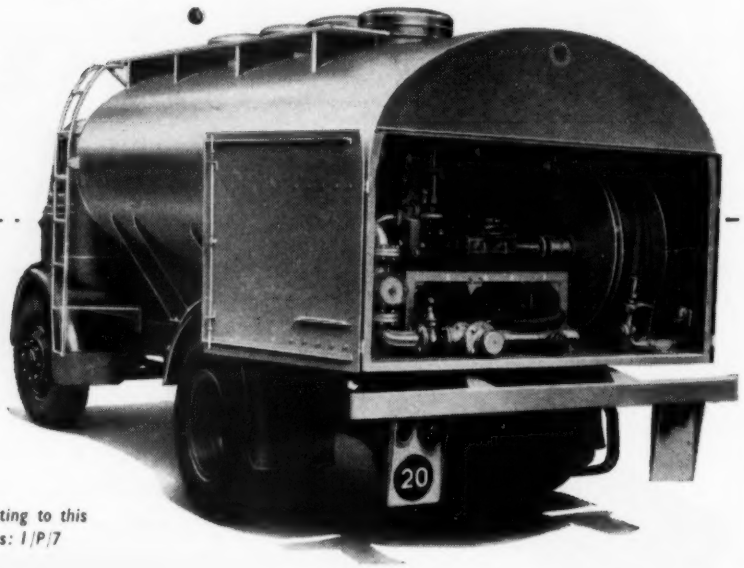

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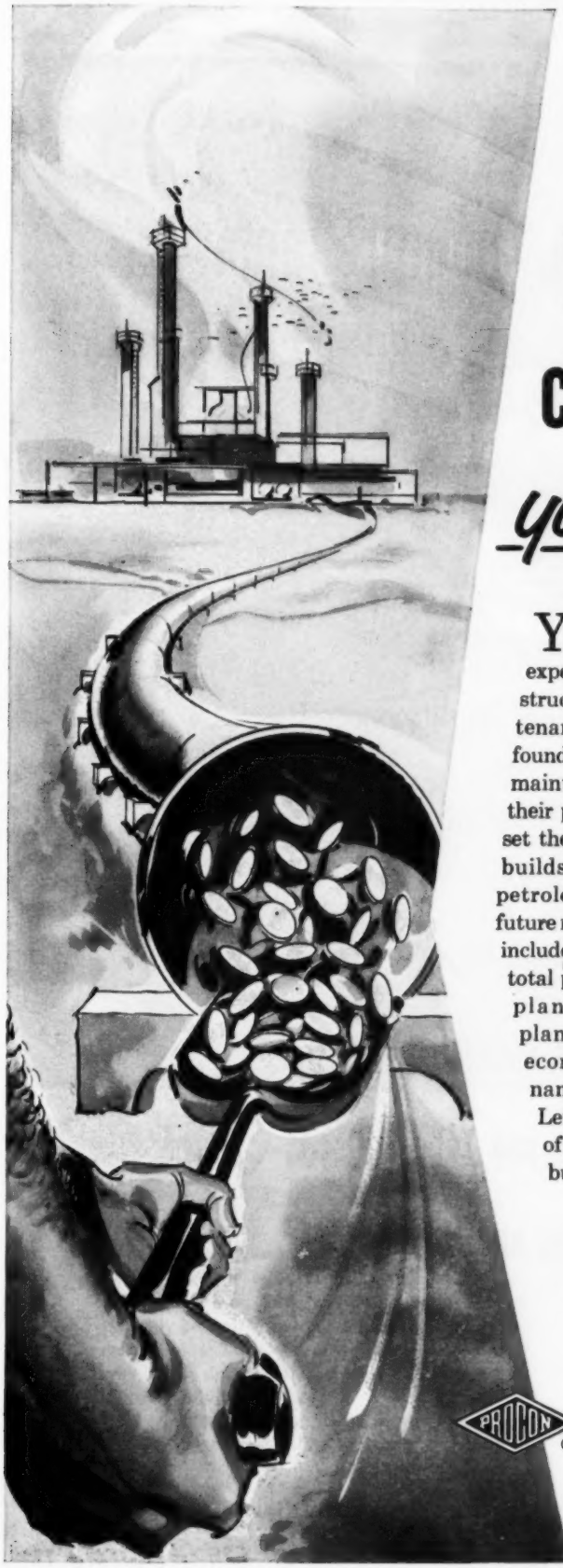

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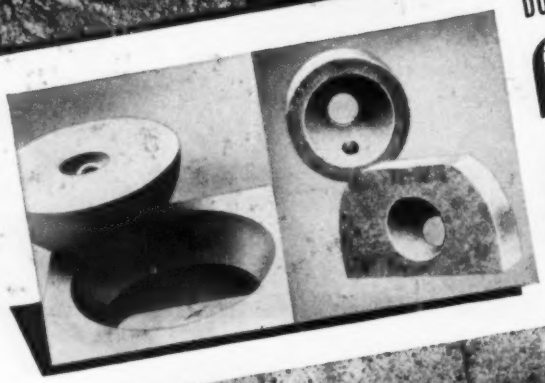

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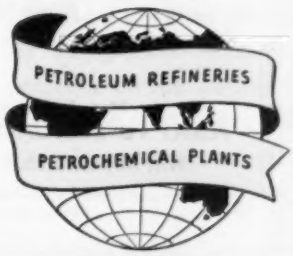

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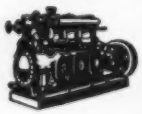

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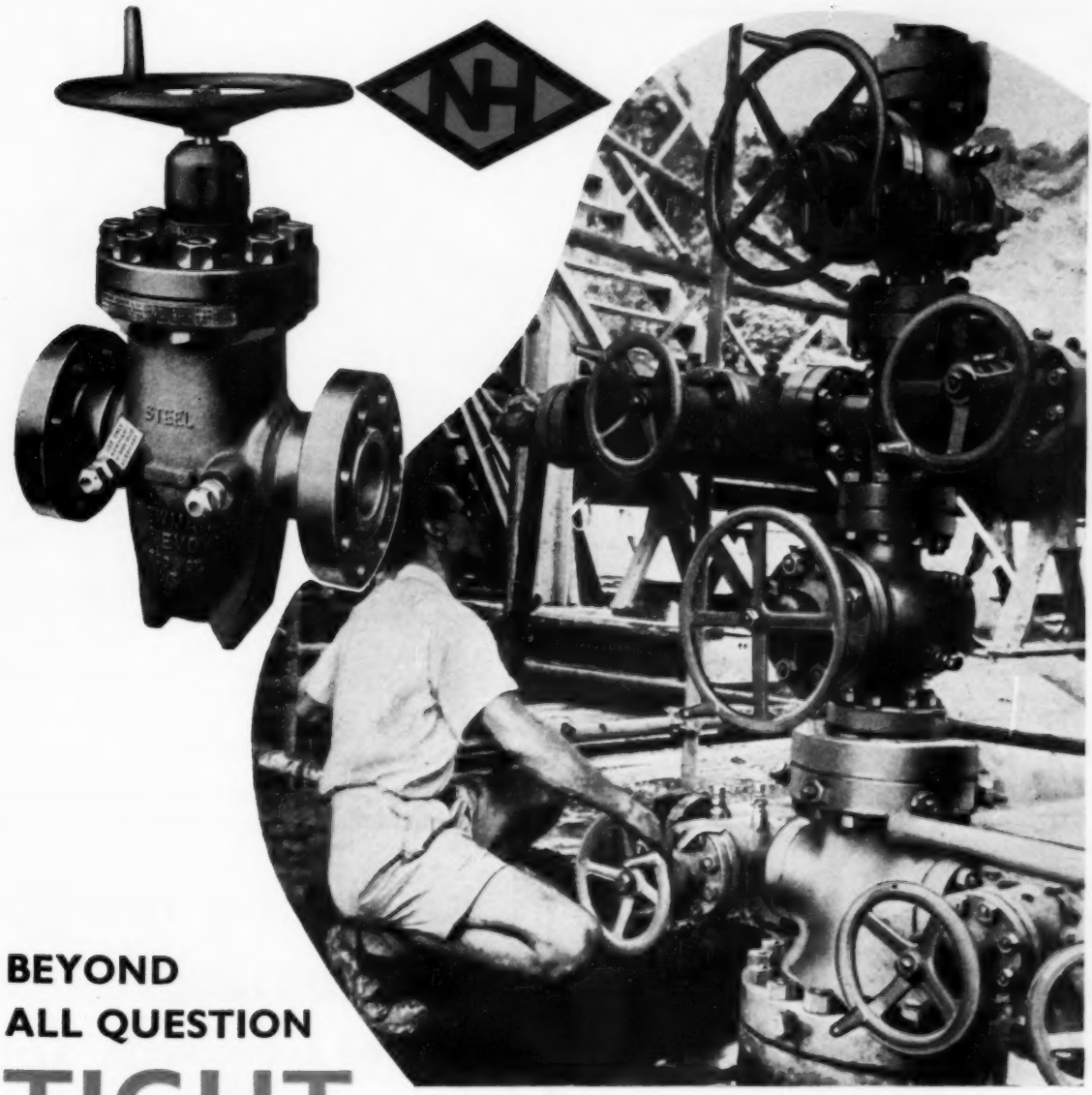

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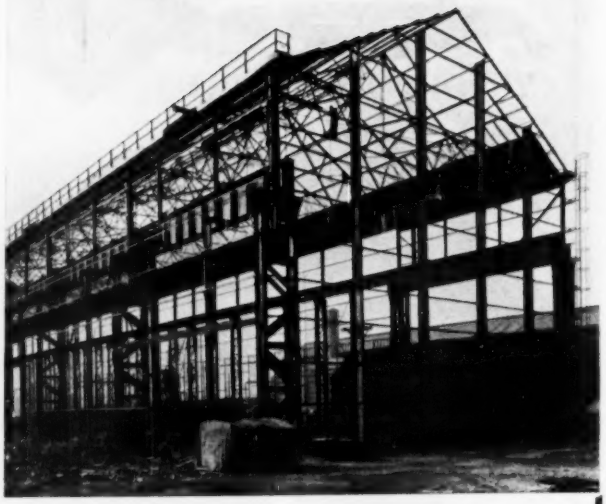

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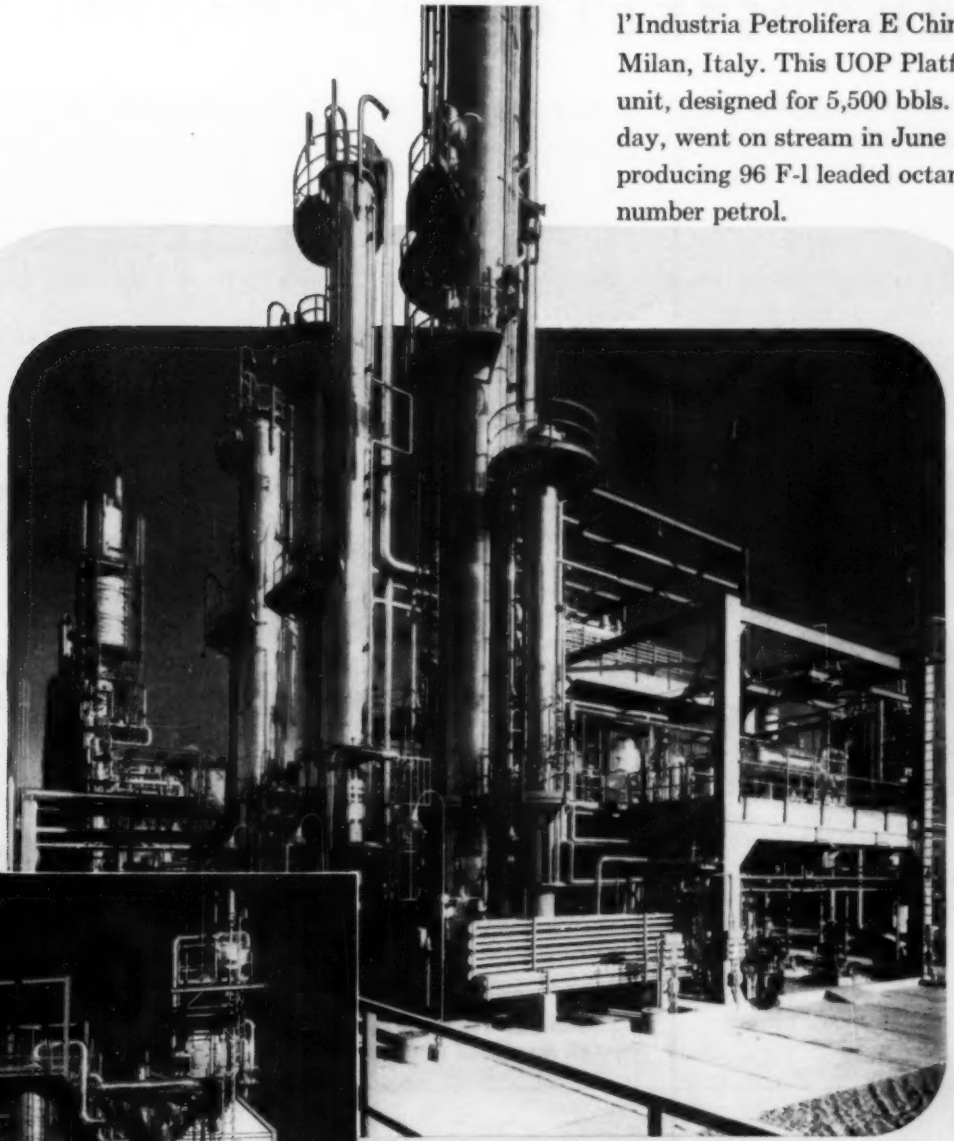

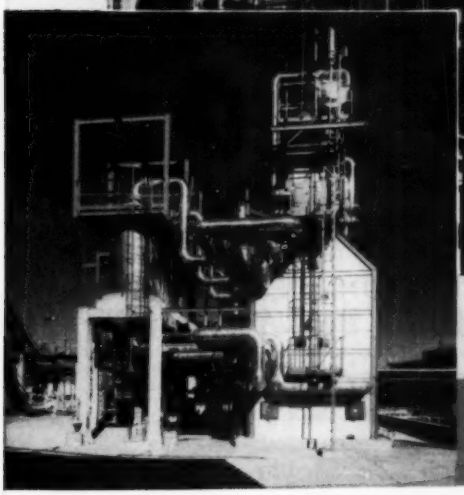

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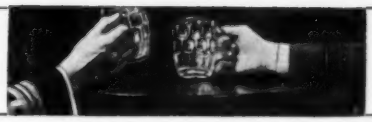

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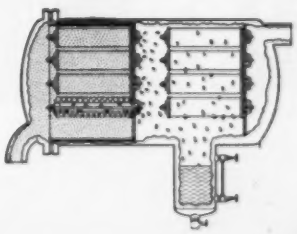

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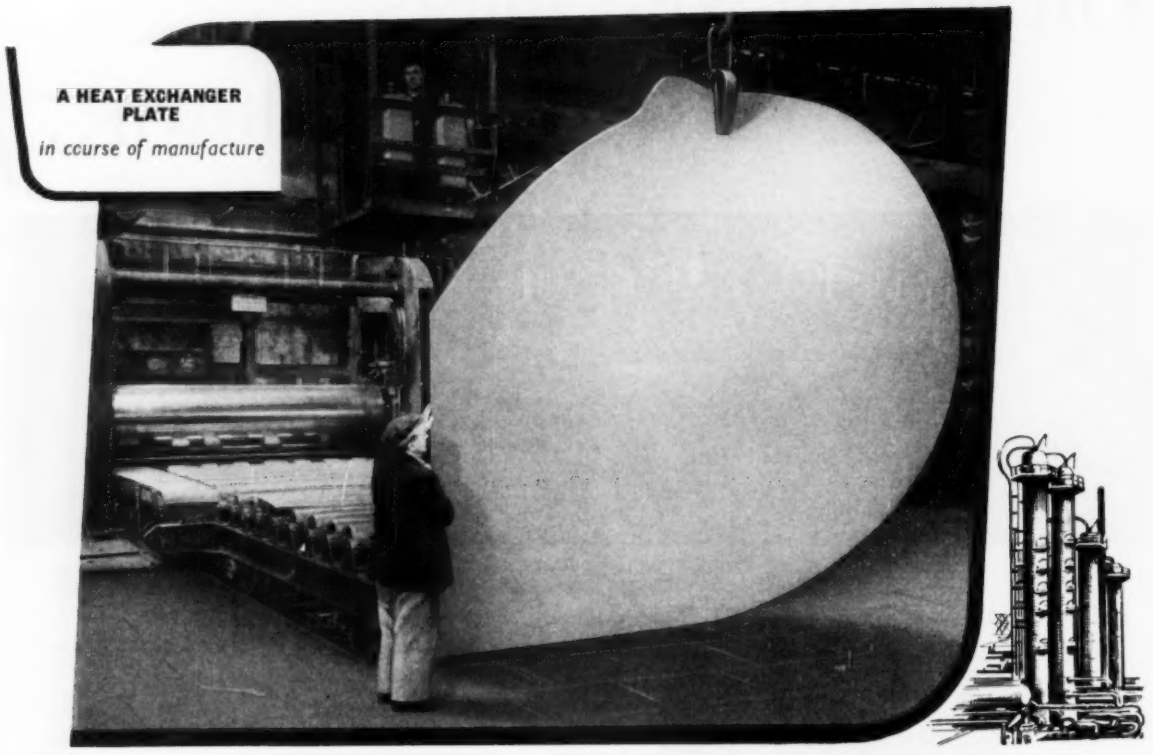

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